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Packard

DEPARTMENT OF THE INTERIOR.
UNITED STATES GEOLOGICAL SURVEY.
F. V. HAYDEN, U. S. GEOLOGIST-IN-CHARGE.

REPORT

ON THE

ROCKY MOUNTAIN LOCUST

AND OTHER INSECTS

NOW INJURING OR LIKELY TO INJURE

FIELD AND GARDEN CROPS

IN THE

WESTERN STATES AND TERRITORIES.

BY

A. S. PACKARD, JR., M. D.

[EXTRACTED FROM THE NINTH ANNUAL REPORT OF THE U. S. GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES FOR 1875.]

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BIBLIOTHECA
REGIA
MONACENSIS

ERRATA.

NOTE.—Owing to the author's absence in the West, proof was not read by him; hence a number of typographical errors occur, which are here corrected.

Page 601, line 20, for *not* read *most.*
Page 608, line 15, for *Pever* read *Peace.*
Page 608, line 19, for *lower* read *locust.*
Page 609, line 37, for *Ball* read *Boll.*
Page 636, line 25, dele *head.*
Page 636, line 27, for *are* read *it is.*
Page 659, line 45, for II read LXIII.
Page 664, line 15 from bottom, for 7, *a* read 6, A.
Page 664, line 13 from bottom, for 7, *b* read 6, B.
Page 664, line 10 from bottom, for 7, *c* read 6, C.
Page 664, line 9 from bottom, for 7, *d* read 6, D.
Page 664, line 6 from bottom, for 7, *e* read 6, E.
Page 665, line 1 from top, for 7 *f* read 6, F.
Page 665, line 5, for *Tremotodes* read *Trematodes.*
Page 665, line 14, for *Chironomas* read *Chironomus.*
Page 665, line 38, for 6, *g* read 6, G.
Page 665, line 5 from bottom, for Smerton read Emerton.
Page 666, line 21, for 7 *a, f, i, and k* read 6 A, F, I, K.
Page 667, line 13, for *h* read H.
Page 668, line 21, for *p.* — read *p.* 622.
Page 673, line 5, for *Eucaliptus* read *Eucalyptus.*
Page 684, line 2, for *white* read *uhler.*
Page 684, line 10 from bottom, for *chorian* read *chorion.*
Page 689, line 18, for (*p.* —) read (*p.* 639).
Page 694, line 25, for *botanist* read *entomologist.*
Page 696, line 6, for 2 *a* read 1 *a.*
Page 696, line 10, for IV read LXV.
Page 696, line 19, for *larva remains* read *larvæ remain.*
Page 707, line 38, after *p.* insert 696.
Page 712, line 37, after *Army-worm* insert *Leucania.*
Page 713, line 26, for *cenalium* read *cerealium.*
Page 713, line 38, for *Anguilluta* read *Anguillula.*
Page 715, line 18, for 6 read 7.
Page 718, line 25, for 8, *b*, read 9 *b.*
Page 719, line 7 from bottom, for *nitella* read *nitela.*
Page 720, line 2 from bottom, for *ches* read *elus*.
Page 725, line 29, for *Le Bauer* read *Le Baron.*
Page 726, line 4 from bottom, after *Fig.* insert 1, *c*, Pl. LXVI.
Page 727, line 2 from bottom, for *craspiena* read *crassispina.*
Page 727, line 5 from bottom, for *sejeanii* read *dejeanii.*
Page 729, line 40, for *heed* read *breed.*
Page 730, line 7 from bottom, for Fay read Say.
Page 730, line 9 from bottom, for *muria* read *murina.*
Page 730, line 18 from bottom, for *cinerea* Foster read *fabricii* Le Conte.
Page 733, line 14, for *clarata* read *clavata.*
Page 755, line 5 from bottom, after *page* insert 732.
Page 767, line 8 from bottom, for 32 read 34.
Page 772, line 12, for *cucumen's* read *cucumeris.*
Page 773, line 16, for *grunt* read *snout.*
Page 774, line 9, for *apüfolia* read *apiifolia.*
Page 774, line 10, for *Pylygonia* read *Polygonia.*
Page 774, line 14, for *Bæhmeria* read *Bœhmeria.*
Page 782, line 2, for *pampinating* read *pampinatrix.*
Page 785, line 20, for 55 read 51.
Page 786, line 1, for *flanda* read *flavida.*
Page 786, line 17, for *Erythionenis* read *Erythroneuris.*
Page 790, line 32, for *Pristophora* read *Pristiphora.*

ERRATA—Continued.

Page 794, lines 14, 15, dele *which may in time leave the oak on which it feeds and attack the apple*
Page 794, line 4 from bottom, for *Le Barm* read *Le Baron.*
Page 795, line 11, for *Le Barm* read *Le Baron.*
Page 802, lines 16, 37, for *Tornicus* read *Tomicus.*
Page 807, line 29, for *Lapper* read *Lappet.*

INDEX.

For *Anisopteryæ* read *Anisopteryx.*
For *Anomys* read *Anomis.*
For *Bæhmeria* read *Bœhmeria.*
For Californian Lapper-Moth read Californian Lappet-Moth.
For *Chocaltis* read *Chloëaltis.*
For *Clisiocampa constrictu* read *Clisiocampa constricta.*
For *Chœnocampa pampinating* read *Chœrocampa pampinatrix.*
For *Dicerea prologata* read *Dicerca prolongata.*
For *Doryphora sejeanii* read *Doryphora dejeanii.*
For *Epicautaue* read *Epicauta.*
For *Erythionenis* read *Erythroneuris.*
For *Eufitchea* read *Eufitchia.*
For *Excorista* read *Exorista.*
For *Eyrytoma* read *Eurytoma.*
For *Haltica cucumenis* read *Haltica cucumeris.*
For *Lugus* read *Lygus.*
For *Meromyga* read *Meromyza.*
For *Pristophora* read *Pristiphora.*
For *Tornicus* read *Tomicus.*

REPORT ON THE ROCKY MOUNTAIN LOCUST

AND OTHER INSECTS NOW INJURING OR LIKELY TO INJURE FIELD AND GARDEN CROPS IN THE WESTERN STATES AND TERRITORIES.

BY A. S. PACKARD, JR., M. D.

LETTER OF TRANSMITTAL.

PEABODY ACADEMY OF SCIENCE,
Salem, Mass., April 29, 1877.

DEAR SIR: I herewith present a report on the Rocky Mountain locust and other insects injurious to the field and garden crops of the Western Territories, including a few injurious species found on the Pacific coast, which section of our Union is happily remarkably exempt from noxious insects. I have included in the report a few forms found injuring the timber-trees of Colorado, and described others, which, from the habits of their allies in the Eastern States, will undoubtedly in future years be more or less destructive. I have also introduced accounts of certain eastern species which will probably from time to time be transported to the Western States and Territories east of the great plains. Accounts of the cotton army-worm, the northern army-worm, as well as the tobacco-worm, etc., are introduced to give completeness to the subject.

My report is partly based on the results obtained in Colorado, Wyoming, and Utah, while attached for seven weeks to your survey, late in June, the whole of July, and early in August, 1875. I have also received assistance from Mr. P. R. Uhler, who, as a member of your Survey, visited Colorado the same summer. My thanks are due to him as well as to Mr. William N. Byers, of Denver, Colo., editor of the Rocky Mountain News, for valuable information regarding the locust, and also to Mr. John L. Barfoot, curator of the Salt Lake Museum, for notes on destructive insects in Utah. Acknowledgments and thanks are due to other gentlemen whose names are mentioned in the following pages.

Some of the matter relating especially to eastern insects is taken from my own notes made for a number of years past in Maine and Massachusetts. I should also acknowledge the important information and illustrations derived from the nine annual reports of Prof. C. V. Riley, State entomologist of Missouri; from the fourteen annual reports of Dr. Asa Fitch, State entomologist of New York; as well as Harris's "Treatise on the Injurious Insects of Massachusetts." Some of the facts and a large proportion of the illustrations are taken from my "Guide to the Study of Insects," published by Henry Holt & Co., New York, and from the "American Naturalist."

In preparing the accounts of the Hessian fly, wheat-midge, the wheat joint-worm, and chinch-bug, as well as the cotton army-worm, I became painfully aware of the unreliable and fragmentary nature of our knowledge of the distribution and habits of these insects, and of the great need of a systematic and thorough inquiry into their natural history.

The facts here presented may often seem disconnected and desultory, but few except experts in natural history are perhaps aware how difficult a task it is to follow out the transformations of any particular insect, and study thoroughly its habits in its different stages of growth. Unlike fishes, birds, and quadrupeds, which have similar habits at all stages of growth, an insect, with its three separate stages of larva, pupa, and adult, leads, as it were, three lives, with different surroundings, and in each of these stages may be regarded as a different animal. Then it is often extremely difficult to ascertain of what beetle or moth or bee such or such a grub or caterpillar is the young. Our entomologists are not numerous enough, and often, from their time being taken up with the pursuit of their profession, usually not that of science, are unable to be long enough in the field to observe for themselves the habits of insects. Unfortunately, also, so backward is the science of entomology in this country, that its students are at present fully engrossed with the labor of classifying and describing the adult insects. When it is to be borne in mind that there are within the limits of the United States, probably at a low estimate, 10,000 species of *Hymenoptera* (bees, wasps, ichneumon-flies, saw-flies, etc.), nearly as many butterflies and moths, about 10,000 species of two-winged flies (*Diptera*), as many beetles (*Coleoptera*) and bugs (*Hemiptera*), and several thousand species of grasshoppers, etc. (*Orthoptera*), and neuropterous insects, such as dragon-flies, caddis-flies, etc., etc., the whole amounting to upward of 50,000 species of insects, not to speak of the spiders, mites, and ticks, centipedes and millipedes, it is evident that in the mere preliminary work of identifying and properly describing these myriad forms—an intellectual work requiring quite as much good sense, discretion, and knowledge as is shown in the pursuit of medicine, the law, or teaching—it is evident that all this work, which is simply preliminary in its nature, is a vast one, and that the combined exertions of many minds over several generations will not exhaust the subject. As it is, there are in this country only about thirty entomologists who publish anything relating to insects. Necessary as it is, this work of classification is by no means the highest and most useful branch of natural science. He who studies carefully the habits and structure of one insect, and, if it is injurious to agriculture, lays before the farmer or gardener a true story of its life, is a true benefactor to agriculture, and at the same time benefits science more than he who describes hundreds of new species.

We have little idea how many kinds of insects are preying upon our field and garden crops, our shade, ornamental, and forest trees. There are, probably, within the limits of our country 5,000 different kinds, which are either at present engaged in the work of devastation, or are destined to be, with the growth of civilization, which means in this instance the destruction of the natural food of these insects and the substitution of a similar diet, our choicest grains and fruits, in its stead.

In the densely-populated countries of Europe the losses occasioned by injurious insects are most severely felt, though from many causes, such as the greater abundance of their insect-parasites and the far greater care taken by the people to exterminate their insect-enemies, they have not proved so destructive as in our own land. MM. Pasteur and Quatrefages, whose names are illustrious as original investigators, were commissioned by the French government to study the causes of the silk-worm disease, *pebrine*, and, as the result of their studies, silk-culture, an interest involving millions of dollars, will probably again be restored to France and Italy. It should be remembered that this remarkable result is due, primarily, to the most abstruse researches upon a microscopic plant

by specialists, for the pure love of science. Their cloister studies, put to practical account, saves the destruction of one of the largest agricultural interests in Southern Europe. In like manner, had the United States encouraged the entomologist and botanist in their studies, and caused them to be turned to practical account, we should not have had to give up the cultivation of wheat in the Northeastern States; our cotton-crop could perhaps have been doubled, and our garden and field crops would have regularly yielded a steady return to the producer.

Let us look for a moment at the losses sustained in the United States from the attacks of insects. The annual agricultural products of this country by the last census amounted in value to $2,500,000,000. Of this amount we in all probability *annually* lose over $200,000,000 from the attacks of injurious insects alone. The losses from the ravages of the locust in the border States in 1874 were estimated at $45,000,000. The estimated money loss occasioned by the chinch-bug in Illinois in 1864 was over $73,000,000; in Missouri, in 1874, it was estimated at not less than $19,000,000. The average annual loss from the attacks of the cotton-worm is probably between $25,000,000 and $50,000,000. Add to these the losses sustained by the attacks of over a thousand other species of insects which affect our cereals, forage and field crops, fruit-trees and shrubs, garden-vegetables, shade and ornamental trees, as well as our hard and pine forests and stored fruits, and it will not be thought an exaggeration to put our annual losses from the ravages of insects at $200,000,000. If the people of this country would only look at this annual depletion, this absolute waste, which drags her backward in the race with the countries of the Old World, they might see the necessity of taking effectual preventive measures in restraining the ravages of insects with care and forethought, based on the observations of scientific men. I believe that from $50,000,000 to $100,000,000, or from one-quarter to one-half of this annual waste, could be saved to the country. It is to be hoped now that the National Government has caused the locust evil to be investigated, such other insects as the chinch-bug, cotton-worm, Hessian fly, &c., may hereafter be examined and reported upon.

With thanks for the liberal spirit you have shown in causing the injurious insects of the Territories surveyed by you to be studied, and for the generous way in which this report has been illustrated, thereby greatly increasing its practical usefulness to the people of the Territories visited,

I remain, very truly, yours,

A. S. PACKARD, JR.

Dr. F. V. HAYDEN,
United States Geologist-in-Charge.

INSECTS INJURING CEREALS, GRASSES, ETC.

THE WESTERN MIGRATORY LOCUST, *Caloptenus spretus* of Thomas, appearing periodically in vast swarms in Utah, Montana, Idaho, Dakota, British America, and Colorado, and Texas and Indian Territory, and periodically migrating eastward to Minnesota, Iowa, Nebraska, Kansas, and Western Missouri; a medium-sized grasshopper, with red hind legs, consuming entire fields of grain, corn, grass, etc., eating both stalk and leaves.

As a study of the habits, distribution, and ravages of the western migratory locust is of special importance, and the desire for fresh information regarding the habits of the insect in its home on the elevated

plateau of the Rocky Mountains led Professor Hayden to urge me to give special attention to these points, I shall devote a good deal of space to a description of the habits of this insect, whose ravages have been and are still destined to be so calamitous.

I will first give an account of my own observations in the Western Territories, and then give a general account based on the facts observed by different entomologists, and close with suggestions as to the remedies to be employed and measures that should be taken by Government and State and Territorial authorities to anticipate future invasions. I have not attempted to give a full historical sketch of locust invasions in the line of States lying directly west of the Mississippi River, beginning with Minnesota and ending with Texas, forming the eastern limits of the locust region, since this has already been done by Professor Riley in his seventh and eighth annual reports on the injurious insects of Missouri, and the facts given by him and others are epitomized in the tabular view of the locust migrations inserted near the end of the present report. Mr. Allen Whitman, in his valuable "Report on the Rocky Mountain Locust, for 1876," has given an account of the locust invasions in that State, with valuable notes on the habits of the insect. From the data he has there published I have been able to correct the tabular view of locust invasions I had extracted from my report and published in advance in the American Naturalist for January, 1877. In addition to what is stated in his report for 1876, Mr. Whitman writes me, under date of February 18, 1877: "I cannot find that there was any appearance of locusts in Minnesota in 1855. The only authority that I know for it is the article by A. S. Taylor, in the Smithsonian Report for 1858, which mentions them as appearing on the reservations, or, at least, among the Indians."

THE LOCUST IN COLORADO.

I first saw the effects of the ravages of this locust along the railroad leading from Cameron, Mo., to Kansas City, June 24, 1875. It was stated to me that the devastations of the grasshopper extended over an area of 300 square miles, beginning at a point about 50 miles east of Kearney and extending about 70 miles west of Kansas City. At this date the locusts had left the country two weeks previous, but a few feeble stragglers being left, with red mite under the wings. The corn and wheat fields were bare; now and then scattered, half-eaten corn-stalks indicated the former presence of a flourishing field; rarely had a field been left untouched. It was evident that the swarms were local in their attacks. As regards the devastations of the locust in Missouri in 1875, the reader is referred to Prof. C. V. Riley's "Eighth Report on the Noxious, Beneficial, and other Insects of the State of Missouri," 1876, where ample details are given.

At Lawrence, Kans., the town and surrounding country had been swept by vast swarms, leaving scarcely a green thing, except in one portion of the town which had been left untouched. Until June 25 the air had been filled with locusts flying at a great height, but after that date they were not seen, and but a few stragglers were observed, hopping feebly about the roadside. The marks of their jaws were apparent on the fences and on the bark of apple and peach trees, in which rings had been gnawed. The grounds about one house had been protected by tarred boards nailed to the fence, and by ditches within the inclosure which were emptied as fast as they were filled, at least 70 bushels having been taken out. An attempt was made to save valuable fir-trees by covering them with blankets, the edges of which were kept down by

soil, but still the locusts crept under. Peach-trees were defoliated, the fruit devoured, and the stones left attached to the stems, while the branches were girdled. As the habits of the grasshopper were studied at Lawrence by Prof. F. H. Snow, of the University of Kansas, and published in the Transactions of the Kansas Academy of Science for 1875, I condense his statements as the results of the observations of an accomplished entomologist living farther west than any other trained observer. Professor Snow first observed the recently-hatched locust on the 6th of April. "They were very diminutive in size, and when disturbed by my walking among them, would hop only two or three inches high, looking very much like the grains of sand in rapid motion upon a vibrating acoustic plate." About the 10th of May the young locusts began to desert their hatching-grounds, which, it should be borne in mind, is where the locusts which had arrived from the Rocky Mountain plateau during the previous summer laid their eggs, the latter being the parents of the brood observed by Professor Snow. As these locusts increased in size they spread around, and it was at this time, namely, before the wings are formed, that they were most injurious. In fifty-five days after hatching, the locust acquires its wings and takes flight. They were first seen to rise and take flight, for their final departure, on June 3. By the 12th of June, just two weeks from the time of their last molt, very few remained in the pupa (or partially-winged) condition. The destruction in 1875 was confined to a narrow strip on the eastern border of Kansas, along both sides of the Kansas Pacific Railroad.

Between Lawrence and Topeka the damage was much less than about Lawrence, and west of Topeka I could not see that the crops had been affected. At Fort Riley very few locusts were seen along the railroad-track. Reaching Denver June 26, a few locusts, the remains of the spring swarms, were seen hopping over the ground. At Denver, 5,211 feet elevation, the young hatch from March 15 until May 15; there is an early and a late brood. A farmer told us that he saw the young on the snow March 20, and again after another fall of snow March 28. A month later, about the middle of April, a second brood, and about the middle of May a third brood appears.

At Boulder the injury from grasshoppers had been light; the grasshoppers appeared in greatest numbers about the 1st of May, stripping some cornfields, and destroying about half the crop, and then went up the Boulder Cañon, May 15. They were still not infrequently seen on the plains.

June 30, at Nederland up the Boulder Cañon, I first saw the locusts flying in the air, toward the west, the wind blowing from the east. Their pupæ were very abundant on grass, logs, etc. I was told that they had become fledged on the 25th–27th, and immediately began to fly westward up the cañon. At Caribou (9,167 feet elevation), the grasshoppers had destroyed the first crop. Around the base of Arapahoe Peak, between 11,000 and 12,000 feet elevation, adult winged locusts were seen, but no young.

July 2, in riding from Nederland to Blackhawk, the air was filled with grasshoppers at an altitude of several hundred feet, sailing on the wind and driven eastward. The stage-driver told me that they had been flying five days. The potato-plants were at this point 5 inches high. At Blackhawk, (7,543 feet elevation), the pupæ of the locust was abundant, as well as winged individuals.

At Golden, at base of the Foot Hills (5,729 feet elevation), July 3, the locust had been fledged for five days, and the pupæ were still abundant

mingling with the pale-green pupæ of *Caloptenus bivittatus* and the larvæ and adult of *Œdipoda carolina*.

At Idaho Springs (7,330 feet elevation), July 5, the young larvæ of the locust were smaller than I had yet seen, being about a quarter of an inch long, and in all stages, from the lately-hatched to the pupæ and winged individuals. I was told, however, that the first brood of locusts hatched about the end of April and early in May, but that winged individuals did not appear until June 20. On Gray's Peak, July 7, owing to the coolness of the day, a little snow falling on the summit and rain below, no grasshoppers, wingless or winged, were seen. In Kelso Gulch, near Georgetown, no young were seen, and but a few winged ones. At Georgetown (8,412 feet elevation), on the flats near the town the young were a quarter to one-half an inch long. Mr. R. S. Morrison informed me that the locust at Georgetown begins to hatch about the 1st of June, a month or more later than at Denver, and continues to hatch out until the 1st of July, as the localities differ in height. About June 23, he said, the locusts begin to get their wings, but they do not migrate until August, when they assemble in great swarms on the mountains, and falling on the snow in immense numbers, are eaten by the bears.

July 9, at Floyd's Hill the grasshoppers were seen by thousands flying westward up the cañon. I did not go into South Park, but was told by an intelligent young man that at a point about a thousand feet below the level of the park he saw the locusts flying about June 25.

July 12, in the Garden of the Gods (about 6,200 feet elevation), while there were few to be seen on the ground, the air was filled with them, flying at all distances from 100 to more than 1,000 feet, for their altitude could be approximately measured by the highest sandstone column of the Cathedral Rocks. When a locust takes wing, it rises more readily on a light breeze and flies off in a zigzag course, gradually rising in height until it sails about, if the wind is light, in an uncertain course. In the Garden of the Gods, where the breeze was northeast, they were driven southwest; but farther up the valley, toward Manitou Springs (6,297 feet elevation), when the wind was westerly, they were borne in an easterly direction. Their rapidity of flight seemed to depend on the strength of the wind, and when the latter was light, individuals could be seen flying about in all directions, crossing each other in their flight, but the swarm as a whole were moving with the wind. A few pupæ were seen on the ground.

At Manitou, the locusts are said to have hatched out in April, and to have taken two months to get their wings. A few pupæ were still to be seen in the oats, and in the spring they did a good deal of damage, thinning the oats and devouring the beets and other garden-vegetables. There were few grasshoppers to be seen in the air at half past 8 in the morning, but by 11 o'clock there were many more. There is probably good ground for the popular opinion that they descend to the ground at night and fly up toward midday, flying by day and resting and feeding at night.

At this date I was informed by a man who had just arrived from Fair Play (elevation 9,964 feet) that there were few locusts (*C. spretus*) in South Park (8,000 to 10,000 feet elevation) and Arkansas Valley this summer.

Mr. W. H. Holmes, assistant on the Survey, writes from Southern Colorado that the grasshoppers had "eaten up everything" on the La Plata.

On July 14, I ascended Pike's Peak, and at an elevation of about 8,000 to 9,000 feet found larvæ in the second stage and pupæ of *C. spretus*. Some not more than one-fifth of an inch long were seen clustering

on the fallen trees by the side of a brook, while the adults were flying perhaps 1,000 feet overhead. On the extreme summit (elevation 14,147, Parry's estimate 14,216, feet), the locusts were flying, though not in great abundance, at least 500 feet above the top; some fell with a thud on the rocks and seemed paralyzed or were found benumbed on the snow. I did not notice that they were flying in any determinate direction, but as vast numbers of a green Haltica covered the low alpine vegetation, I judge that as these had evidently been borne up by currents of wind from the plains below, the locusts had been carried up in a similar manner, especially as they were more abundant on that day at an elevation of 8,000 to 9,000 feet. That, however, even at this latter elevation, the winged locusts had probably come from the plains east of the mountains seems evident, as the young born at this altitude had not yet acquired their wings. Indeed, it seems to me exceedingly doubtful whether those born above an altitude of 8,000 or 9,000 feet arrive at maturity if they do acquire wings; their flight is only local, from one cañon to another. It seems evident that the vast swarms which appear occasionally must have been hatched on the plains to the west and northwest, at an altitude of 5,000 to 7,000 feet.

As regards the inferences to be drawn from my own observations in Colorado, which were made between June 27 and July 19, namely, after the spring brood had taken flight and before the late summer swarms had arrived on the plains, I would state:

1. That in the cañons and mountains above an elevation of about 8,000 feet the young were too few in number and too late in their development to supply the material for the swarms that visited the plains about Denver in August.

2. The grasshoppers seen by me sailing in the air between about 6,000 and 9,000 feet elevation were probably derived from the April and May broods of the plains about Denver, east of the foot-hills of the Rocky Mountain Range.

3. The August swarms which spread over the plains about Denver and the country north and south, within a hundred miles or so, originated in Colorado, but probably not the adjacent Territories, and were derived from those bred on the plains about Denver directly east of the mountains, which were borne aloft in June, and then collected in large swarms and migrated back, borne by westerly winds, later in the season, to find suitable places for laying their eggs. It is not improbable that the earliest local swarms, such as devastated the plains of Colorado, bred in the plains about Denver, and gathered for about a month in the lower portion of the mountain valleys into the compact and well-organized swarm which, to some extent, devastated the Colorado Plains. Undoubtedly the sexual instinct leads large swarms, bred during favorable seasons, to migrate in search of broad plains which afford the proper conditions for the deposition of their eggs and the nourishment of their young. But it is evident that the parks and cañons of the Rocky Mountains of Colorado, all of which lie above an altitude of 7,000 feet, present conditions of elevation, climate, extent of territory, and food too unfavorable for the production of the immense swarms which at long intervals devastate the Colorado Plateau and portions of Kansas and adjoining States. It is most probable, however, that the late August and early September broods of locusts noticed by Mr. Byers about Denver may have been born and bred during exceptionally dry seasons in the plains of Wyoming and Montana, and thus appeared in Colorado a month later than those bred east of the mountains. It is doubtful if the young individuals (larvæ) which I saw at different elevations up to

about 9,000 feet ever arrived at maturity; they may winter over and acquire wings in the spring, but this is improbable.

In Northern Colorado the grasshoppers may have in part taken wing from the Laramie Plains of Wyoming and the plateau east of the Black Hills, while the swarms devastating Southern Colorado may have been in part indigenous and in part derived from the plains of New Mexico on the south and Utah on the west.

As I was not able to observe the locust in spring or late in the summer, I am obliged to rely on the statement of others regarding the habits of the locust at these periods. The following letters from W. N. Byers, esq., written at my request, give an able summary of the results of his observations and are of value, as the leading points confirm my own impressions. It will be seen that I quite agree with Mr. Byers's view that comparatively few of the swarms originate in the mountain cañon, as originally stated by the late Mr. B. D. Walsh (based on the statements of Drs. Parry and Velie), and reiterated by others:

DENVER, COLO., *August* 22, 1875.

DEAR SIR: Your letter of 16th instant is before me, and fearing that it may be mislaid or overlooked if not answered until "the close of the season," I will endeavor to reply, so far as able to do so, now.

Some years ago I answered a similar inquiry from Prof. Cyrus Thomas, also of Dr. Hayden's Survey, and I think it found place in some one of the reports. My opinion respecting the hatching-fields, &c., of the grasshopper was then seriously questioned, but Professor Thomas, after another year's observation and study, freely admitted that I was right. I presume you have seen what I wrote at that time, or if you have not, that you can readily do so. My opinions have not changed since. I may here say that I first made the acquaintance of the destructive grasshopper in 1852, about the 1st of August, upon the plains of Northern Utah and Southern Idaho, at which time they were flying east-northeast in swarms that obscured the sun.

Their breeding-places may be in any part of this arid portion (the western half) of the United States. The *great* swarms that attain maturity and migrate are hatched, doubtless, within altitudes ranging from 4,000 to 7,000 feet above sea-level. At 7,000 to 8,000 feet they may so far mature as to make short flights and remove to new localities not far distant. Above 8,000 feet they seldom, if ever, become able to fly, though I have seen myriads of them hatched at 10,000, 11,000, and even up to 12,000 feet above the sea. Probably they did not attain more than one-third of their growth before being destroyed by autumn frosts and snows.

The most favorable hatching-grounds are the plains like this east of the mountains, upon which are situate Denver, Pueblo, Greeley, Cheyenne, Fort Laramie, &c., from 4,000 to 6,000 feet above the sea. Where they settle down to propagate their species they must have subsistence; hence theré must be fertility and vegetation. As to the latter, they are not very particular, but are sure to take the best there is. Sexual union begins in August and the deposit of eggs soon after, and both continue then until stopped by severe frosty weather, say in October. They choose, first, plowed ground; second, comparatively loose sandy or gravelly land, partially but not thickly covered with grass or other vegetation; third, the most favorable spots where they may happen to be and from which they are not able to get away. The female, with her nether extremity, perforates a hole in the ground about as deep as the length of her body, and deposits a cluster of eggs that resemble in size and form the eggs of the caterpillar-moth attached to the twig of an apple or cherry tree, except that in the place of the twig there is a hollow space. They are cemented together by a glutinous substance, which is doubtless impervious to water. The eggs deposited, the hole above them is soon filled and leveled by wind or rain. In a warm winter young grasshoppers are frequently found hatching out at various periods. They have been noted here in November, in February, March, and April, but of course only in limited areas and small numbers; and such do no harm, being soon destroyed by cold. The main hatching begins about the second week in May, and lasts, say, a month. At higher altitudes, from 7,000 to 12,000 feet (if eggs happen to have been deposited there, which is rarely the case), the hatching continues from the above dates until the last of August or even into September, owing to the altitude. But from all these latter no harm need ever be feared.

The flight of moving swarms is governed mainly by the prevailing winds, although they seem to be controlled somewhat by choice or laws of their own. A change of wind, or particularly a sudden chill, even slight, brings a flight of them quickly to the ground; but if the next day is fair and warm, and the wind favorable, they again

circle into the upper air and resume their flight. They may tarry for several days, their march depending upon the weather and the sun's warmth—the warmer the better for them.

The "cañons of the mountains" (a very prevalent idea in the East) produce but *very few* grasshoppers—probably not 5 per cent.; the higher cañons none that ever leave them.

I suppose that the swarms that devastated Nebraska and Kansas in 1874 were natives of the plains of the Upper Missouri branches, the Yellowstone, Powder River, and the North Platte—that great plateau-land lying between the Black Hills and Rocky Mountain chains in Montana and Northern Wyoming.

The same flights overspread Eastern Colorado in 1874, destroyed the late crops and deposited their eggs. The latter hatched out in May and June (very irregularly), and the young ate up the early crops, and one, two, and in some cases three subsequent plantings. In July most of them took flight, but frequent swarms have appeared since in various parts of the Territory, and they are now doing considerable damage in several counties. Their movements this year have been very erratic and entirely uncertain. These various flights—none of them very numerous—have been in various directions, and there seems as yet little disposition to deposit eggs. I am told that most of them are afflicted with parasites, and if so they will soon disappear. They perished from that cause in 1865. It would be easy to learn exactly the nature and habits of this plague, provided observers can be secured all over this arid region. They afflict some portion of it every year. The scourge only moves from place to place. If Government can secure report, for instance, from every district in which they hatch next spring, then trace the flight of the moving swarms during the summer and fall, their habits can be accurately determined. It is a far more simple task than the operations of the Signal Service Bureau.

If at any time I can serve you further, or if you desire more definite report this fall of the season's results, please let me know.

Meantime, believe me, very truly, your obedient servant,

WM. N. BYERS.

A. S. PACKARD, JR., M. D., *Salem, Mass.*

HOT SULPHUR SPRINGS, COLO., *October* 1, 1875.

DEAR SIR: In response to your postal card of August 30, I have but little more to report respecting the grasshopper. I have studied them with some care here this fall, and will give in brief the result. The first flights came to this neighborhood in the first week of August—not numerous—and most of them disappeared in three or four days. In the second week of August others came and in great numbers, and they have remained ever since. I was absent the latter half of August. In the first week of September I was again here and found them pairing. Many of the females were boring holes and appeared to be depositing eggs, but on examination it was found that very few actually were deposited. The bottom of the hole generally contained a small quantity of frothy, gelatinous matter, such as accompanies the eggs; but I think in only two instances during that week did I find eggs, and then only six to ten. The next week, however, brought on the height of the season. Myriads were boring in the ground everywhere, and from one-half to two-thirds of the perforations were found to contain from 15 to 30 eggs each, from one inch to two inches below the surface. In many places the earth was perfectly honeycombed by their nests. At this time (the second week in September) they had begun dying quite rapidly, and the living were feeding largely upon the dead. As the season advances they subsist more and more upon the dead and eat less vegetation. Now (October 1) they are eating the dead and dying when not too torpid to care about eating at all.

I was again absent the last half of September, and have returned but two days ago. There are still plenty of grasshoppers here, but most are dead. Occasionally a couple are seen paired, but I have found none depositing eggs.

I learn that last year eggs were deposited in North Park and that they hatched there in countless swarms the present season. I presume our flights came from there. At any rate we are certain of the young ones here next year. The altitude here is 7,725 feet above the sea. The west half of the park escaped them. They extended but five or six miles west of this point; that is, the swarms that deposited eggs. The first swarms (1st to 5th of August) were more general, but did not stay.

About Denver, and over a large portion of the agricultural country in that neighborhood, the flying swarms were bad in the latter part of August, but most of them moved on. Only in a few and comparatively limited neighborhoods were many eggs deposited.

Of those that died here a few were killed by a parasite, developing a maggot which eats out the body of the grasshopper; but the great majority perished from exhaustion and cold—old age, perhaps.

Very truly, yours,

WM. N. BYERS.

A. S. PACKARD, JR., M. D., *Salem, Mass.*

P. S.—Since writing the above I have made another grasshopper survey, and find numbers of them yet depositing eggs.

By the same mail with this I send you a small box of the eggs. I find in some places the ground at the proper depth is fully *one-fourth* filled with their eggs. From this you may form some idea of their incredible numbers. I find also that numerous burrowing insects, worms, &c., are living off them.

W. N. B.

The earliest swarm of which I can find authentic information is one seen at Boulder, Colo., by Professor Robinson, and whose history he has kindly given in the following account. It seems impossible that this swarm which began its migrations so early as July 20 could have been raised among the parks or cañons of the mountains. We are forced to the conclusion that they were bred on the plains, and collecting and massing east of the mountains were borne by westerly currents beyond the usual breeding-grounds of the species across the plains to Eastern Kansas.

UNIVERSITY OF KANSAS,
Lawrence, Kan., October 11, 1875.

DEAR SIR: I will very gladly give you my observations upon the swarming of the locusts from the Rocky Mountains eastward in the summer of 1874.

I arrived at Denver on my westward trip about the 23d of June. During a stay of six or seven days in the city, I made frequent excursions to the neighboring country, visiting "ranches," rambling through fields of grain and over the prairie, with eyes wide open for locusts, potato-bugs, &c., of whose ravages I had previously read many reports. At this time I found very few locusts anywhere, not enough to do any perceptible damage to vegetation. About the 1st of July I went over the Snowy Range down into Middle Park. Here I eagerly renewed my search for locusts, urged on by the desire to use them as trout-bait; and you may be sure I hunted them vigorously, for with nearly every locust I could catch a fine trout. But the trout were far plentier than the locusts. Coming out of the mountains about the 20th of July, by way of Golden City, just at the base of the foot-hills, I encountered the advance of an immense swarm of locusts sweeping from the north, filling the air from the ground upwards for hundreds of feet. Two or three miles from the hills their flight appeared to swerve somewhat more toward the east. I passed through the swarm about five miles from where they were first encountered. The next day they settled down to business in the wheat-fields near Denver.

The 28th of July, leaving Denver for Lawrence, I overtook them at Salina. The 13th of August they first appeared in Lawrence. They staid about ten days, long enough to eat everything green, and then passed on to the southeast. Where food was abundant they traveled slowly. They were ten days in going from this place to Olathe, 27 miles farther east, and five or six weeks in reaching Sedalia, Mo.

Yours, respectfully,

D. H. ROBINSON.

In addition to the facts regarding the locust in Colorado in 1875, I may cite the following facts from Professor Riley's eighth report. Mr. N. C. Meeker, of Greeley, writes that "on the plains, they appeared late in April and the first of May; along the foot-hills in May; in the timber-region and along the Snowy Range from June to July. * * About the 1st of July, the first hatched in the plains-region departed toward the south. A week ago (August 20) those hatched in the Blue Mountains came down upon us and then departed in a southeasterly direction; but now we are having them from the Snowy Range in what may seem incredible numbers. Their numbers, however, are almost nothing in comparison with the myriads that keep southward every day about noon. I estimate that they cover in the sky east and west a space twenty or thirty miles wide, while they move in a body half a mile deep. They consume about two hours in passing, and we can estimate from this statement how much ground they would cover if they should all alight." It seems from this extract that so far north as Greeley the locusts came late in August from over the mountains to the westward, and not

from the north, *i. e.*, Wyoming; while those hatched earlier in the season on the plains, went southward. "Signal-service observations made at Denver show that from the 20th of July to the end of August swarms repeatedly passed, and invariably from the north and northwest, notwithstanding that the prevailing direction of the wind was from the south." (Riley's report.)

I also add a letter from Mr. Meeker, published in the New York Tribune:

GREELEY, COLO., *May* 25.

We are trying every way we can think of to drive away the grasshoppers, and we are now in the midst of the battle, but the wounds of the conflict are mainly inflicted by the insects. Ordinarily, the grasshoppers are not hatched out of their eggs until the 1st of June. Before this period the ground is so wet and cold in consequence of the spring rains that the insects are not hatched out. This year we had no spring rains to speak of, hence the ground was warm and dry, and the insects appeared about the 25th of April. At this time the wheat was just starting, and the insects ate it as fast as it grew. Our wheat is sown in February and March, and it is of a superior quality, better than the winter-wheat of the Eastern States. If there had been the usual spring rains it would have been at least a foot high by the time the grasshoppers appeared.

Wheat that is starting is greatly injured by being irrigated, and usually it does not need irrigation. If the soil is light the water quickly cuts gulches which constantly deepen, and flooding the ground all over is impossible, especially if the land inclines any way. But after the grain has grown to some height its roots fill the surface-earth and the water cannot cut through them, and it forces its way hither and thither among the blades of grain, much as one is obliged to do in a crowd of men. So it spreads over the field and evenly with a little aid. When wheat is in this condition, and the young grasshoppers are hatched in sandy places open to the sun, they cannot eat the wheat as fast as it grows, and besides it is an easy matter, by irrigating the fields, to drown them, or at least to keep their numbers small. But even when they are eating the wheat in a half a dozen fields, or in a dozen fields in one neighborhood, as fast as it grows, there will be many other fields where the wheat is not molested, and by the time the pests are grown and have wings to fly a large breadth of wheat will be strong and vigorous, and consequently will mature. Usually, therefore, the young grasshoppers—which came to our fields only once before, two years ago—do but little damage, and the average yield of wheat during the year mentioned was as great as that of the Eastern States; while in ordinary years it is more than double. In this place and all through Colorado the gardens are as bare as in January, for no attempt has been made to plant vegetables. The grasshoppers do not touch pease, however, and these are growing fast.

But most of the mourning is about the condition of the wheat-fields. We have on the northwest about 4,000 acres sowed with wheat, and owned by thirty or forty farmers. The wheat is all gone, and that region looks like a desert. It is true that there are a few fields in the midst left, but we expect to hear every day of their destruction northeast and east of the railroad and along what is called Free Church. The owners are constantly on guard. When an advance detachment of grasshoppers appears it is attacked with fire and water, and thus for the present the enemy is kept at bay. On this side of the river, all the five-acre, ten-acre, and twenty-acre lots are without vegetation. To the south there are several hundred acres of wheat where the wheat is over knee-high and growing as if in arace for its life. We may save 500 acres of wheat out of 5,000, which will give us bread, but we expected to have obtained $150,000 from this year's crop. Meanwhile we are waiting. Corn will be planted in hundreds of fields within ten days. All kinds of garden-vegetables are now growing in boxes in the houses, waiting their chance to appear with safety in the outer air. I expect to sow half an acre of beets and get a large return. There is no seed-wheat in the country; if there were a crop could be grown; and there is scarcely corn enough for seed. There is no barley, nor have the farmers money to buy any.

All this is a fair description. As a people we are certainly better off than those further east, because we have water at our command, because our stock-range is preserved, giving to those keeping cattle their usual returns, while our mines of silver and gold are unfailing. But these resources do not help our farmers at all. There are some families now utterly destitute. Every dollar they had or could borrow was put into the ground, and it will never return. Friends of such in the East should help them if possible. Probably county commissioners can give some relief; the legislature may; Colorado is entirely out of debt. The grangers can do nothing for each other, for all are involved.

The total destruction of crops between the Mississippi and the Rocky Mountains is appalling, and I estimate that the number of people afflicted is nearly three mil-

lions. We, here, do not believe a word in the statements made from time to time that the grasshoppers are dying, or that a parasite is eating them. We have seen them come out of water, mud, and snow as strong as ever. They are "iron-clad." I wish I were as sure of one proposition as I am that a machine will be invented that will take them up from the ground and "leave not a wretch behind."

Additional facts regarding the occurrence of the locust (*C. spretus*) in Colorado and other Territories will be found in the following extracts from an article in the Daily Inter-Ocean, Chicago, October 9, 1875, from the pen of Prof. Cyrus Thomas, State entomologist of Illinois:

Their hatching-ground is known to extend over the vast area roughly designated by the following boundary-lines: On the east, the one hundred and third meridian; on the south, the south line of Colorado and Utah; on the west, the west line of Utah extended north to British America; the northern line being somewhere in British America—even this area in the northern part being expanded indefinitely east and west. Now for the proof. While connected with the United States Geological Survey, under Dr. Hayden, for four years, I traveled over a large portion of this area, traversing it on various lines east and west and north and south, studying somewhat carefully the habits of these destructive locusts. During this time I noticed them in the larva and pupa state, or depositing their eggs at the following places: At various points along the east base of and in the bordering valley of the mountains in Wyoming and Colorado, from North Platte near Fort Laramie to the Arkansas River; in Laramie plains, and around Fort Bridger; from Utah Lake, in Utah, to Fort Hall in Snake River Valley, Idaho; in Northwestern Dakota near the Red River of the North; and on both sides of the range in Montana along the valleys of Deer Lodge River, and the branches of the Upper Missouri. I also obtained satisfactory proof of the same thing occurring in British America, north of Dakota; in Middle Park, Colorado; and in the regions west of that point; in Wind River Valley, in Wyoming; in Central Montana along the Yellowstone, and in the Green River country west of South Pass. These facts, which are but a small portion of what might now be gathered, will give some idea of the work necessary to be done if we undertake to exterminate these insects by destroying their eggs in their native haunts. If it can be shown, which is doubtful, that the progenitors of the swarms which visit Kansas and Nebraska, after sweeping down from the mountain regions, deposit their eggs within the limited area heretofore mentioned as the point of departure east, then, and then only, is it possible to devise a preventive measure applicable to their native haunts, as this, with the exception of a comparatively small region around the headquarters of the Missouri, is the only portion of the broad plains lying along the east flank of the mountains susceptible of an extensive system of irrigation. Before alluding to their operations in Kansas, Nebraska, and other bordering States, I will present some facts in regard to their migrations in and from the mountains and northern regions which will assist the reader in forming a more correct idea of their habits and the extent of their operations; and here be it remembered I confine myself to the single species *Caloptenus spretus*. I have traced a swarm from the area west of South Pass to their stopping-place and hatching-ground north of Fort Fetterman, from Northeastern Dakota nearly to Lake Winnipeg, and have ascertained that some swarms have even extended their migrations, from some supposed southwest point, as far as the north side of this lake. It is also known that in one instance, at least, those which left Colorado moved in the direction of Texas; those visiting Salt Lake Valley have repeatedly come from the northeast, sometimes, doubtless, from Cache and Bear River Valleys, and at others from the Snake River region, while those hatched in Salt Lake regions moved south, in some instances returning with the change of wind. In 1864 those hatched east of the mountains in Northern Wyoming and along the Yellowstone in Montana swept down the east flank of the range upon the fields of Colorado, while a part moved east to Manitoba and Minnesota. In 1867 a swarm from the west side of the range poured into Middle Park and there deposited their eggs, but those hatched from these failed to scale their rocky bounds; yet, while these were vainly striving to leave their mountain prison, another horde from the barren regions beyond sweeping above them over the snowy crest, poured down upon the valleys east; and in another instance a swarm was seen passing for two days over Fort Hall from the southwest. On the other hand we find them extending their flight far into Texas in destructive hordes, yet New Mexico and Arizona appear to be comparatively free from them; at least the very extensive collections made by Lieutenant Wheeler's expeditions in these Territories during the last four years, which have been submitted to me, contain but very few specimens of the *C. spretus*, and during my visit to New Mexico in 1869 I found scarcely any specimens south of Raton Mountains, although comparatively abundant in Colorado, and even in San Luis Valley. I am therefore inclined to doubt the correctness of the statement made in reference to the grasshopper in these Territories in 1855, if intended to apply to this species.

These facts, if added to the experience of the last three years in Kansas, Nebraska, Dakota, Minnesota, and Manitoba, will suffice to show, not only how extensive their range is, but also how varied their flight is, and that there are no particular spots which can be said to form their permanent hatching-grounds. That they prefer the elevated sandy plateaus and terraces in the mountain districts is certain, but that any particular localities form the permanent hives from which the swarm issue cannot be maintained. Yet that those which visit Kansas and Nebraska, and even Dakota and Minnesota, originate usually within a certain portion of the mountain region appears highly probable. While there are some exceptions to the rule, yet it is evident that the general course of their flight east of the mountains is southeast. The distance traveled by any particular swarm, so far as I am aware, has never been positively ascertained, yet enough is known to indicate that this may extend for at least two or three hundred miles. The hordes which visited Colorado in 1864 are supposed by Colonel Byers to have originated in Montana, along the Yellowstone; and the swarm which I traced through Sweetwater Valley probably traveled over 200 miles; yet the evidence is not positive in either case, though strongly presumptive.

Maj. J. W. Powell informs me that in August, 1867, he encountered vast numbers of locusts in the region northwest of Pike's Peak, as he drove his wagons for five days through them, traveling at the rate of 20 miles a day. It is not probable that this was *C. spretus*.

In August, 1875, Mr. P. R. Uhler visited Colorado, and sends me the following notes on *C. spretus*:

When I first reached Golden, on August 6, small flocks of the *C. spretus* were flying from the direction of northwest (over the peaks evidently) and alighting on the hills and upon the crops in the irrigated fields; but these were nothing to the hordes which poured into the country near Manitou about August 13–16.

All the flocks that I saw consisted of *C. spretus*. I met with this species everywhere, from north of Denver to south of Cañon City, in the mountains and on the plains. But I did not see them as far east as Bijou. Perhaps they don't love that locality. And I noticed that the flocks alighted in particular spots, and did not appear all over the plains and hills west of Colorado Springs. Evidently they preferred some spots to others of the same kind of surface-soil.

In the Proceedings of the Davenport Academy of Sciences, Mr. J. D. Putnam writes as follows regarding his experience with the locust in Colorado:

I have collected this species in various parts of Colorado. It was quite plentiful on the plains between Denver and Boulder City in June, 1872, and later in the season I found it abundant in the mountains at Empire City. On August 1 they were very abundant high up above the timber-line on Parry's Peak. Vast numbers were chilled by the snow and lay at the base of the snow-drifts in heaps. They could be seen, filling the air like snow-flakes, to a great height above the extreme summit of the peak, 13,133 feet. The wind was from a westerly direction. In September, this year (1872), I found them in great abundance in Middle Park. In 1874 I first noticed this species on Gold Hill, Boulder County, July 8, and on July 11 they appeared at Valmont and other places on the plains in great abundance, and did great damage. They received several large re-enforcements during the following week. After remaining several days, these seemed to disappear, but only to make room for another swarm; and thus they kept coming and going during the rest of the summer until nothing eatable was left. At Empire City they were very abundant during the whole of my stay, from August to October, but they seemed to eat but very little, if anything. At Cañon City, in October, I found them very abundant. They were very sluggish, and the sidewalks were covered with the dead and dying. Large numbers were seen paired. The young grasshoppers hatched out abundantly early in April, 1875. In 1873 I found them in different parts of Western Wyoming, between Fort Bridger and the Yellowstone Lake; but on the plains bordering the Stinking Water River, in July, they were more abundant than I had ever seen them elsewhere before. In June, 1875, I collected a few near the transfer depot at Council Bluffs, Iowa. This is the most eastern locality I have yet seen it. In Utah last summer I failed to see a single specimen, although I looked specially for it. (Page 265.)

THE LOCUST IN WYOMING.

In going from Cheyenne to Salt Lake City, July 19 and 20, over the Union Pacific Railroad, no locust was seen, and the absence of insect-life within the limits of Wyoming was remarkable. As soon as the

borders of Utah were approached, insects (but not the locust) became abundant. The locust, however, breeds as abundantly in Wyoming as in adjacent Territories, and is evidently one of the sources of supply for the swarms which invade Colorado. In proof of this I will first quote Professor Thomas, who makes the following statement in Hayden's Annual Report for 1876 on the Geology of Wyoming:

During the expedition of the present year, while traveling up the North Platte, between Fort Fetterman and Red Buttes (August 20–23), we observed vast numbers of this species. They were not on the wing, having to all appearances ended their flight, and were now pairing, doubtless intending to deposit their eggs there. Frémont encountered a similar swarm in passing over this part of the North Platte Valley. He remarks: "This insect has been so numerous since leaving Fort Laramie that the ground seemed alive with them; and in walking a little moving cloud preceded our footsteps. They had probably ceased their flight, and were preparing to deposit their eggs. By reference to my present report on the agriculture of this section it will be seen that here there appears to be an almost constant current of air sweeping down the Platte Valley from the west. When we reached South Pass City, I learned from Major Baldwin that about the first of the month (August) a large swarm had crossed over the pass from the west, moving eastward, and that they had not gone to Wind River Valley. I am satisfied that they did not go upon the Laramie Plains, as I visited that section twice during the season. Nor did we meet with any swarms during our passage up the Sweetwater; we may, therefore, reasonably infer that those we saw on the North Platte were the same that crossed the mountains at South Pass. From whence did they come? As we heard nothing of them during our passage down Big Sandy along the stage-road, I infer that they must have come from the northwest; but what distance I have no means of ascertaining."

Capt. W. J. Jones states in his "Report upon the Reconnaissance of Northwestern Wyoming," made in the summer of 1873, that in the Green River Basin "the region is infested with great swarms of grasshoppers." We have seen that Mr. Byers surmises that some of the swarms which devastate Colorado cross the Snowy Range from the Green River Valley.

THE LOCUST IN UTAH.

This Territory is much freer from the invasions of locusts than Colorado. In 1875 they were scarce, and had not been abundant for three years, all that were seen being evidently indigenous. In gardens in Salt Lake City, and in fields at Lake Point, in Salt Lake, in July, 1875, they were less frequent than the yellow-striped grasshopper (*Caloptenus flavovittatus*). I found them not unfrequently in Utah, though Mr. J. D. Putnam remarks: "In Utah last summer (1875) I failed to see a single specimen, although I looked specially for it." (Proc. Davenport Academy of Sciences, 266.) The invasions, as several persons told me, are from the north and northwest, the latter being the direction of the prevailing winds in summer. The swarms coming down from the north are sometimes turned back by the south winds, and when the wind changes over Salt Lake multitudes are drowned. The gulls, so common on the lake, were seen feeding on grasshoppers along the beaches. *Caloptenus spretus* is undoubtedly distributed over the entire Territory. Mr. J. L. Barfoot, of Salt Lake City, in charge of the museum, told me that he had received specimens (which I saw in the museum) from Kanab, in Southeastern Utah, and also from Dirty Devil Mountain. Professor Thomas also reports it as breeding in the southern and western line of Utah. In his letter to me Mr. Byers states that he first saw the locust in 1852, about the 1st of August, upon the plains of Northern Utah and Southern Idaho. Professor Thomas also gives the following data regarding its occurrence in Utah, in Hayden's Report on the Geology of Wyoming, 1870, p. 283:

As heretofore stated, they have been very destructive in Utah for the past three years, not only injuring very materially the growing crops, but eating the leaves from

the fruit-trees to such an extent as to injure the fruit. From Dr. A. T. McDonald, of Provo City, I learned the following particulars in regard to the incursions of this insect into the Territory: That the prevailing cold and winter storms are from the northwest, but that the grasshoppers seldom come from that direction. On the contrary, they generally come from the northeast, through the cañons, being brought in by the local currents which sweep through these mountain openings, and that they generally pass off in a southwest direction, though the swarms that come in often remain and deposit their eggs, from which another brood arises in the spring. Sometimes, after a swarm has departed to the southwest, the wind changes, and they are driven back to be swallowed up in the lake or perish in the valley. The time of coming varies from the middle of May to the middle of August. The eggs that are deposited here usually hatch out in April and May. The growing crops receive their greatest injury from the young which are hatched in the valley. The usual method of fighting these young gormands is to drive them into the irrigating ditches, where they are drowned in the water. When they are a little older they are often checked by scattering straw along the edge of the ditches, and driving them into it early in the morning, and then firing it; those which are not destroyed by the fire being caught in the water of the ditch and drowned. But these methods of combating them are practicable only when they are in the larvæ and pupa states.

Dr. McDonald says that in Utah, at least, the females deposit their eggs in the ground in sacks—a fact heretofore noticed and published—on the gravelly elevated plateaus, or foot-hills. And from my observations this season I am inclined to agree with him in the opinion that these elevated table-lands, which are composed of coarse sand and gravel, and but slightly covered with vegetation, are the principal hatching-grounds of the migratory swarms. The local broods are to be found all over the Rocky Mountain region, from Raton Mountains as far north as I have been, and as far west, at least, as Salt Lake Valley. These are found hatching out in the grassy valleys and broad plains of the lower lands and up the mountain cañons almost to the snow limits. And these broods appear to have little or no connection with the migrating broods; but the solution of these questions will require more extended observations by those who can distinguish the species.

I also extract from Mr. Thomas's remarks on the same subject in Hayden's Report on the Geology of Montana, 1871, p. 451:

Caloptenus spretus.—Found the past season [1871] in great abundance in the north part of Salt Lake Basin. When we reached Ogden, June 1, I saw but very few specimens; but when we reached Box Elder Cañon, two weeks later, the larvæ were seen spreading out from points where they had evidently been hatched. When we passed through the hills to Cache Valley, a few miles farther, and but a few days later, I found them just entering their perfect state. By the time we reached the north end of the valley, about the 20th of June, they were taking wing and proceeding southward. Here the farmers, who have observed them closely for a number of years, say that they never lay their eggs in the lower level of the valley, but universally on the gravelly elevated terraces. So positive are they on this point that one farmer, to test the matter, last year offered $5 for every bunch of eggs that could be found on the lower valley level which had been deposited there by the insect itself, but none were brought to him. I think, therefore, we may concinde that it is pretty well settled that the usual hatching-grounds of the destructive swarms are on the gravelly terraces or uplands. Yet that considerable numbers are hatched in the narrow cañons of the moderately-elevated mountains I think is also certain, as I observed this year a large number of larvæ in Box Elder Cañon; but the elevation of this cañon is little, if any, more than that of Cache Valley. When I returned to Salt Lake Basin, early in August, I found the country swarming with myriads of these grasshoppers. And even after we had passed eastward on the railroad, to the heights near Aspen Station, I noticed the air filled with their snowy wings, but could not tell exactly the course they were taking, but thought they were moving southwest.

The following statements, which are quoted nearly word for word, are made by W. Woodruff and A. M. Musser in a Mormon paper. The locust appeared in Utah in the year 1855, and again from 1866 to 1872, inclusive. In 1855 they came from the west, in 1866 from the north. The subsequent years' products were produced from eggs, while relays came from all directions. They hatched out from April to June, and in 1855 and 1872 left in August and September, flying north and east, in dense clouds obstructing the sunlight. In 1855 foreign swarms came about July, in 1866 about September, and deposited eggs.

In 1855 about 75 per cent. of the cereals, vegetables, and fruits were destroyed by them. The following spring the people subsisted largely on thistle, milkweed, and other roots.

When eggs are not disturbed by the plow frost does not destroy them. During the years named they visited all parts of the Territory. Thousands of bushels were destroyed by the organized labors of the people, by driving them and burying them in trenches, by setting traps in irrigating ditches, by covering the ground with straw, under which they would shelter for the night, and in the morning burning the straw and insects. Men, women, and children, with the village poultry, in some places, moved to the fields in wagons and fought the common enemy from hatching to flying time. In some parts, it was estimated there were one hundred bushels of hoppers to the acre.

A notable local mathematician estimated that in *one season, one and a half million bushels* were destroyed by lighting in Great Salt Lake and drifting on the shores, forming an immense belt.

THE LOCUST IN NEW MEXICO.

Professor Thomas also states that it breeds in Snake Valley, Idaho. That it is common and destructive at times in New Mexico is shown from the statement published in the Monthly Report of the Department of Agriculture, at Washington, D. C., for July, 1876, where it is stated that the corn and oats were injured and the wheat-crop half destroyed by the "grasshopper," which must be *C. spretus*, as Taos is near the Colorado line. Professor Thomas reports a few specimens of *C. spretus* from New Mexico and Arizona in collections made by Lieutenant Wheeler's Expeditions during the last four years, and he himself found a few specimens south of Raton Mountains in 1869. In 1875, however, Lieutenant Carpenter, as he writes me, did not see any swarms in the region extending from Fort Garland to Santa Fé. "I could not learn," he adds, "that they had ever been troublesome in northern New Mexico."

THE LOCUST IN NEVADA.

Prof. Cyrus Thomas has kindly afforded me the following facts regarding the occurrence of *Caloptenus spretus* in Nevada, in a letter dated March 1, 1877:

I saw *C. spretus* in 1871 in abundance along the Humboldt River in Nevada, most of the way from where the Central Pacific Railroad strikes it (going west) to the sink or place where it disappears. At one point they were quite abundant, and evidently preparing to migrate, flying up in the air, their wings presenting that peculiar glassy, snowy appearance with which you are no doubt familiar. This, if I recollect rightly, was west of Humboldt Station; they were quite abundant at that station (Humboldt), where we dined, (going west), but were not migrating there or then; those referred to as seen west of Humboldt being seen as we returned east. You probably remember that saline or alkaline belt at the northwest extremity of Great Salt Lake; just beyond that I began to observe them, and from thence—not continuously, but at certain points—from there to, and a short distance west of, Humboldt Sink. The collections made by Wheeler's party in Southeast Nevada had no specimens which I could positively say came from that section. That year (1871), as we went out (June), we saw but few specimens in Salt Lake Valley, but they were quite numerous when we returned from California in August. They were also numerous in Cache Valley and Southern Idaho; in moderate numbers west of the range in Montana as well as east.

From the facts thus afforded by Professor Thomas, it is not improbable that this species in its normal form will be found to commonly occur in the treeless regions of the entire State of Nevada, and also of the eastern half of Oregon, and also, perhaps, of Washington Territory, west of the Sierra Nevada, to the south, and the Cascade Mountains to the north. Among these ranges, and to the westward, when the rain-fall is very considerable, and the land clothed with forests, we are to look for the non-migratory variety, *Atlanis*, which may there exist under conditions resembling those in which it lives in the Mississippi Valley, and the forest-clad Atlantic States and Canada.

It will be exceedingly desirable to trace the distribution of *C. spretus* southward of the present known limits, for it is not at all unlikely that it inhabits the Mexican Plateau, since Major Powell informs me that he found a locust, as he thought this species, numerous within twenty miles of the Mexican boundary on the Colorado River.

In Northern New Mexico Lieutenant Carpenter found this species (identified by Mr. Scudder) on Taos Peak, Sangre de Cristo Mountains, at a height of 13,000 feet (above timber-line), in July, 1875. (Scudder in Wheeler's Annual Report for 1876.)

NORTHERN RANGE OF THE LOCUST.

While the locust (*C. spretus*) breeds in Wyoming, Montana, and Dakota, in some cases swarming northward and eastward into the region about Manitoba, its northernmost limits in British America are said by Mr. G. M. Dawson* to be "the margin of the coniferous forest which opportunely follows the line of the North Saskatchewan River." As regards the northeastern limits, Mr. Dawson says: "The locusts are recorded, on one occasion at least (1867, by Professor Hind), to have reached the shores of the Lake of the Woods, but I have not heard that they did so in 1874. Their limit in this direction is pretty definitely fixed by the western margin of the great woods, about longitude 96°. They did not appear at Fairford Port, on the northern part of Manitoba Lake, nor at Lake Swan House (longitude 100° 30′, latitude 52° 40′), Cumberland House (longitude 102° 30′, latitude 54°), Prince Albert (longitude 105° 30′, latitude 53° 10′), or Fort Pitt (longitude 109° 20′, latitude 53° 30′).

They are very seldom seen at the second, and never at the third and fourth of these localities. The exemption of Prince Albert is noteworthy and instructive, as, on the testimony of several gentlemen acquainted with the locality, it is due to a *belt of coniferous timber*, which stretches between the North and South Saskatchewan Rivers here; and though grasshoppers in great abundance have visited the country south of the line thus formed, *they have never been known to cross it*, as will be seen farther on; that in 1875 great numbers flew westward to the Lake of the Woods.

Regarding its appearance at Manitoba in 1875 I quote as follows from Professor Dawson:†

From the reports now received from Manitoba and various portions of the Northwest Territory and published in abstract with these notes it would appear that during the summer of 1875 two distinct elements were concerned in the locust manifestation. First, the insects hatching in the province of Manitoba and surrounding regions from eggs left by the western and northwestern invading swarms of the previous autumn; second, a distinct foreign host, moving, for the most part, from south to north. The locusts are known to have hatched in great numbers over almost the entire area of Manitoba and westward at least as far as Fort Ellice on the Assineboine River (longitude 101° 20′), and may probably have been produced, at least sporadically, in other portions of the central regions of the plains, though in the summer of 1874 this district was nearly emptied to recruit the swarms devastating Manitoba and the Western States, and there appears to have been little, if any, influx to supply their place. Still farther west, on the plains along the base of the Rocky Mountains, from the forty-ninth parallel to the Red Deer River, locusts are known to have hatched in considerable numbers; but of these more anon.

Hatching began in Manitoba and adjacent regions in favorable localities as early as May 7, but does not seem to have become general till about the 15th of the month, and

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* Notes on the Locust Invasion of 1874, in Manitoba and the Northwest Territories. Montreal, 1876, 8vo, p. 16.

† Notes on the Appearance and Migrations of the Locust in Manitoba and the Northwest Territories, summer of 1875, by George M. Dawson, Assoc. R. S. M., F. G. S. (From advanced sheets of the Canadian Naturalist.)

to have continued during the latter part of May and till the 15th of June, while, according to Mr. Gunn and others, in cold, clayey land and where pools of water from the melting of the snow lay long, isolated colonies came out at still later dates. Mr. Gunn states that grasshoppers were even noticed to hatch in August and September in spots which had been covered with water all summer, a fact showing the very persistent vitality of the eggs, and apparently negativing opinions which have been expressed as to their destruction by damp. The most northern locality at which locusts are reported to have been produced from the egg is at Manitoba House, Manitoba Lake (latitude 51°).

The destruction of crops by the growing insects in all the settled regions was very great, and in many districts well-nigh complete. The exodus of these broods began in the early part of July, but appears to have been most general during the middle and latter part of that month and first of August. The direction taken on departure was, with very little exception, southeast or south. It is to be remarked that as there does not seem to have been during this period any remarkable persistency of northwest or northerly winds the insects must have selected those favoring their intended direction of migration, an instinct which has very generally been observed elsewhere. Though most of the parents, in 1874, came from the west and northwest, and Manitoba must have represented to those ending their flight there the southeastern limit of their range, the young insects of 1875 thus took a southeastward direction, just as though starting from their usual breeding-grounds in the far Northwest, and showed no disposition to return to the region whence their parents came. This direction of flight carried many of the insects at once into a country of thick woods, swamps, and lakes, and caused the repetition of the phenomenon of the appearance of grasshoppers in great numbers about the Lake of the Woods, a circumstance only once before noted, in the summer of 1857.* This previous occasion, however, differed from that of last year in being an extension of an invasion of Manitoba from the west or northwest and not resulting from insects hatching in that province.

It is probable that most of the grasshopper swarms of Manitoba thus entering the wooded country were there harmlessly spent, for though some northern swarms reached the State of Minnesota, the invasion appears to have been comparatively unimportant. Northern swarms are noted to have passed over Crookston (Polk County, Minnesota) and Fort Totten (Dakota), the greatest number appearing at the latter place July 19. The locust swarms described by Mr. Riley† in the following paragraph, from information furnished to the Chicago Tribune, dated July 13, probably also came from Manitoba: "The first foreign hoppers appeared on the Sioux City Road, alighting between Lake Crystal and Saint James on Wednesday last. A few days later they were observed at New Ulm flying southeast, and at noon of the same day struck the line of the road at Madelina, Saint James, Fountain Lake, Windom, and Heron Lake, covering the track for about 50 miles of its length." It will be observed on referring to the summary on another page that the insects produced in Minnesota itself flew southwest in the early part of July.

I have not been able to trace further the movements of these Manitoba broods, unless indeed it be supposed that some at least of the swarms which passed over Central Illinois early in September came from that quarter. These, however, Mr. Riley believes not to have been the true migratory locust, *C. spretus*.

Foreign swarms from the south crossed the forty-ninth parallel with a wide front stretching from the ninety-eighth to the one hundred and eighth meridian, and are quite distinguishable from those produced in the country from the fact that many of them arrived before the latter were mature. These flights constituted the extreme northern part of the army returning northward and northwestward from the States ravaged in the autumn of 1874. They appeared at Fort Ellice on the 13th of June and at Qu'Appelle Fort on the 17th of the same month, favored much, no doubt, by the steady south and southeast winds, which, according to the meteorological register at Winnipeg, prevailed on the 12th of June and for about a week thereafter. After their first appearance, however, their subsequent progress seems to have been comparatively slow and their advancing border very irregular in outline. They are said to have reached Swan Lake House, the most northern point to which they are known to have attained, about July 10, while Fort Pelly, farther west, and nearly a degree farther south, was reached July 20, and about seven days were occupied in the journey thence to Swan River Barracks, a distance of only 10 miles. It is more than probable that the first southern swarms were followed by others, which mingled with them, or even, in parts of Manitoba and the country immediately west of it, with the indigenous brood. From a few localities only in Manitoba, and those in its western portion, is the evidence pretty conclusive as to the arrival of foreign swarms from the south. Burnside, Westbourne, Portage la Prairie, Rockwood, and Pigeon Lake may be mentioned as affording instances.

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* Not 1867, as erroneously printed in Notes for 1874.

† From Mr. Charles V. Riley's very interesting Eighth Annual Report on the Noxious Beneficial and other Insects of the State of Missouri.

Many of the grasshoppers observed, according to reports received by Mr. Riley, in Dakota, at Fort Thompson, Yankton, Fort Sully, Springfield, Fort Randall, and Bismarck flying northward and northwestward at various dates in June and July, no doubt eventually found their way north of the forty-ninth parallel. Those seen at Bismarck about June 6 and 7 probably belonged to the earliest southern bands above referred to, and, judging from the dates given by Mr. Riley, may have been produced in Nebraska, or more probably even still farther south. A portion of the southern and eastern army probably reached Montana, and may even have penetrated in diminished numbers into the districts in the vicinity of Bow River.

A considerable number of locusts appear to have hatched at about the same date as in Manitoba near the extreme western margin of the plains, especially in the country near Bow River. Foreign swarms arrived at Fort McLeod from the southwest, depositing eggs; and most of those hatching near Bow River, and farther north, seem to have gone southeastward early in August. No very definite or wide-spread movement of swarms appears, however, to have occurred during the summer of 1875 in this region, nor, if we may judge from the very meager accounts received, in the corresponding portion of Montana.

During the summer of 1875, the conditions described in the Notes for 1874 as occurring in the region west of the one hundred and third meridian were reproduced in Manitoba, and over a great area of the Western and Southwestern States, with results even more disastrous to the crops than those of the winged invasion of the previous year. We do not hear of any access of fresh swarms to Manitoba from the west or northwest, nor is it probable that any such occurred, notwithstanding the fact that in various parts of the province flights are reported to have passed over from northwest to southeast. From the dates and descriptions given, it seems certain that these were only those from the more remote parts of the province itself, and in many cases the broods hatched in any locality mingled with those coming from a little distance, and departed at the same time.

The most remarkable and exceptional feature in connection with the appearance of the locusts in 1875 is the extensive invasion of the wooded region east of Manitoba by the swarms produced in the province. This is the more noticeable when contrasted with the immunity enjoyed by Prince Albert on the Saskatchewan, alluded to in last year's Notes, which is owing to its separation from the general area of the plains by a belt of timber. On writing to Mr. Clarke, of Carleton House, on the subject, he informs me that this protecting belt of fir-timber is only four miles in width, and extends completely across between the north and south branches of the Saskatchewan. Judging from the above remarkable fact, and the known habits of the locust, I do not think that the incursion made into the forest-country can be looked upon as anything but exceptional, and perhaps showing that the locusts had lost their reckoning. Nor do I believe that it should discourage the cultivation of belts of woodland, which promises to effect in time a general and permanent amelioration of the grasshopper plague.

Broadly sketched, the movements of the locusts in 1875 conform to a general plan. All those hatching in Minnesota, Manitoba, Northern Dakota, and in the high western region of the plains, at least as far south as Colorado, on obtaining their wings, went southward, and this in some instances regardless of the direction from which their parents had arrived in the previous year. Swarms produced in Nebraska, Missouri, Kansas, Texas, and Indian Territory flew northward and northwestward, returning on the course of their parents, which had flown southeastward from that quarter. This movement can be traced over an immense area, from the northern borders of Texas almost to the Saskatchewan River.

Evidence appears to be fast accumulating to show that the general and normal direction of flight for any brood is to return toward the hatching-grounds from which their parents came, and it would seem that to complete the migration-cycle of the locust two years are required. The tendency which the swarms show to migrate on reaching maturity cannot be wondered at, as it is so commonly met with in other animals, and may be assisted by the mere lack of food in the district which has for a long time supported the young locusts. The fact, however—let us call it instinct or knowledge—that the young, while amenable to the migratory tendency, show a determination to exercise it in a direction exactly the opposite of the preceding generation is most remarkable

Professor Dawson writes me that, "during the summer of 1876, the grasshopper was scarcely seen in Manitoba, and a fine crop was harvested all over the province. Manitoba is safe for next summer, unless *invaded*. I have reason to believe, however, that during last summer the locust was very abundant in the far West, on the plains east of the Rocky Mountains, and north of the forty-ninth parallel. With regard to this region, however, I have only general information."

Through the kind suggestion of Prof. G. M. Dawson, of the Canadian

Geological Survey, I have received from Mr. Sanford Fleming, engineer-in-chief of the Canadian Pacific Railway, a copy of a "Map of the country to be traversed by the Canadian Pacific Railway to accompany progress-report on the exploratory surveys, 1876; Sanford Fleming, engineer-in-chief." On this map the "southern limits of the true forests" are laid down* on a line running in a general northwest direction from a little to the eastward of Fort Ellice, in about latitude 54° 30′, longitude 110° 10′. This line is indicated on the map showing the distribution of the red-legged locust (*C. femur-rubrum*). "The northern limit of true prairie-land" is also copied on the same map from Mr. Fleming's map. It runs from Turtle Mountain on the forty-ninth parallel, a little east of south of Fort Ellice, and runs in a general parallel course to the limit of forests, and ends at the Bear Hills, just south of the fifty-second parallel of latitude and in longitude 108°. Professor Dawson writes me that "no map yet shows even approximately the area of the Pever River Prairies, but these are separated by forests from those to the south, and are never invaded by *C. spretus*." This is most important and satisfactory information, and confirms Professor Dawson's statement as to the northeastern limits of the lowest area, which are herein already quoted. It would seem doubtful whether the Rocky Mountain locust breeds abundantly north of the Little Slave Lake. The data afforded by this map also confirm me in my indications of the western limits of the prairie region and temporary and periodical breeding-places of the Rocky Mountain locust, which probably follows approximately the meridian of 102°, pursuing a sinuous course indicated by a range of hills put down on the United States maps, from which Mr. Bechler has compiled the maps accompanying this report. The barren plains extend just north of the forty-ninth parallel as far east as longitude 104°, and this may be the southeastern limits of the permanent breeding-places of the locust north of the forty-ninth parallel.

That the return swarms from Missouri, Kansas, and Nebraska may reach British America is suggested by Mr. Allen Whitman in his report for 1876:

Whether or not it is a general rule that the locusts on acquiring wings seek the direction from which their parents had come in the preceding year (a rule which the experience of Minnesota fails to substantiate), it is certain at least that in 1875 "the main direction taken by the insects that rose from the Lower Missouri Valley country was northwesterly." (Riley's Eighth Annual Report, p. 105.) These swarms were traced by Professor Riley, moving northerly from the end of May through June and into July, and passing various points in Dakota, Wyoming, and Montana.†

They passed northward over Bismarck at various times between June 6 and July 15. (Same report, p. 86.) But a still more definite statement as to the final destination of these northward-moving swarms is found in an editorial of the Winnipeg Stand, of August 19, 1876, entitled "Locust flights." It is there stated that in 1875, "the locusts which hatched in Missouri, Kansas, and Nebraska, in an area of 250 miles from east to west, and 300 miles from north to south, took flight in June, and invariably went northwest, and fell in innumerable swarms upon the regions of British America, adjoining Forts Pelly, Carlton, and Ellice, covering an area as large as that they vacated on the Missouri River. They were re-enforced by the retiring column from Manitoba, and it seemed to be hoping against hope that the new swarms of 1876 would not again descend upon the settlements in the Red River Valley. Intelligence was received

* Professor Dawson informs me that this is taken from Palliser's Map, published as a blue-book by the British government, forming a part of the report on explorations in British North America.

† He adds (page 108): "Nor can I learn of any instance where these swarms that left our Territory deposited eggs." The different case of our own breed of locusts, laying eggs within two weeks after flying commences, is remarkable. But I am informed by Capt. J. S. Poland, commanding at Standing Rock, that a swarm from the south alighted near that post July 4, 1875, and deposited considerable quantities of eggs between the 4th and the 18th of July.

here that the insects took flight from the vicinity of Fort Pelly on the 10th of July, and then followed a fortnight of intense suspense."

There is, of course, in all this a failure to connect by any direct chain of continued observations the swarms that left the Mississippi Valley in 1875 and those which finally disappeared in the region of the mountains and in British America; still less is it shown that those swarms were the parents of those which are known to have hatched in the same regions in 1876, or even that those which are known to have hatched there were those which descended upon the lower country in July and August. But there is, at least, a strong series of probabilities.

THE INVASIONS OF THE LOCUST IN 1876.

Beginning with the southeasternmost point of the locust region—

Texas: I learn from G. W. Belfrage, of Clifton, Bosque County, in a letter dated December 14, 1876, that the locusts have for "two years made their visits, the first without serious results, the second this fall, so we cannot yet know what the offspring will do."

The following extracts from the Monthly Weather Reports give some idea of their movements: "Flying, at Fort Richardson, Texas, from 14th to 18th September; Corsicana, Texas, flying south 21st and 22d, west 23d. On 30th were destroying everything, and depositing millions of eggs."

In Texas, at Belmont farm, the grasshoppers remained alive all winter, and were found on wheat February 10 and March 25.

October 3 to 5, numerous at Corsicana; disappearing about 9th; abundant at Belmont farm 1st to 9th. "In Texas a dense cloud of grasshoppers appeared during the last ten days of November."

"*Palo Pinto:* The grasshoppers appeared on the 17th of September, and are as thick as they ever were here, destroying everything as they go. *Uvalde:* Appeared September 22, in quantities, arriving from the north, and causing some alarm. *McLennan:* Reached here on the 20th of September, and have materially damaged the cotton-crop by cutting off unripe bolls. *Bell:* Made their appearance in great numbers about a week since, and are destroying all gardens and every sward of grain. They have cut off the late corn and the young bolls on the late cotton. *Dallas:* Have cut short the cotton-crop. *Gillespie:* The first grasshoppers arrived on the 18th of September. Three days later they left, going west, being driven by an east wind."—(Agricultural Report, October.)

On applying to Mr. J. Ball, a well-known entomologist residing in Dallas, Tex., for information regarding the appearance of the locust in that State, he kindly sent me the Neue Zürcher Zeitung for November 1 and 2, 1876, containing two letters written by him, which I have condensed as follows: In October, 1874, the locusts appeared in Texas, but were not one-tenth as abundant as in 1876. At Dallas, at noon September 20, 1876, the air was filled with the first swarm of locusts; by 5 o'clock in the afternoon none were in the air. Previous to this date up to the night of the 19th the wind had been south; it changed on the 20th to the northwest, and this wind brought the locusts in a swarm which must have been many miles long and broad, and from 1,000 to 2,000 feet high, as far as the eye could see. At 10 o'clock, September 21, the air was again filled as at noon of the preceding day, the northwest wind still blowing, and the grasshoppers passed on as the day before, until 4 p. m. On the 22d the wind veered to the south, and the locusts flew during the day in large numbers irregularly about, like a swarm of bees. This continued until noon of the 23d, when a southwest wind bore a large number to the northwest. Until the 27th they remained engaged in egg-laying.

They laid their eggs in an unbroken, somewhat sandy soil, in little pockets buried several lines deep. Mr. Ball counted several hundred holes in a square foot of soil. They did not lay in cultivated, plowed land, and should they do so, plowing would be sufficient to destroy almost all the eggs. From the observations he made, Mr. Ball concludes that this great plague will diminish as the cultivation of the soil increases, and will finally be abated, as in Germany the locust invasions are much less numerous than formerly.

At Fort Gibson, Indian Territory, they appeared September 16 to 28. North of Texas, in Arkansas, Kansas, Missouri, according to the Monthly Weather Review, August 6, grasshoppers appeared at Lamar's, Nodaway County; Oregon, Mo., flying north 1st; northwest 2d, 4th, 6th; south 11th and 19th; northwest 22d; southwest 23d and 25th; and south 26th. For other details the reader is referred to Riley's Ninth Report, as State entomologist of Missouri), and Minnesota, as well as Iowa, according to the Monthly Weather Review, the locust appeared late in summer and laid their eggs, which will hatch out in greater or less numbers in the spring of 1877.

THE LOCUST IN NEBRASKA IN 1876.

How they swarmed in Nebraska last autumn may be seen from the following extract from a correspondent of the New York Tribune:

The grasshoppers are here. They have come to stay, and are busy perpetuating their species. Early in August they reached the western portions of this State, but were partial in their depredations, devouring everything in some localities, doing little damage in others. On the 12th of the month they made a forward movement, and appeared in the valleys of the Elkhorn, Platte, and Republican. Our local papers, acting on the "ostrich" policy, suppressed the facts or misrepresented them, and all were wishing for a favorable wind to carry the pests beyond our borders. But a soft, southerly wind, varied by an occasional thunder-storm from the northwest, prevailed till the 23d, when, aided by a stiff northwester, the grasshoppers rose and came from their exhausted feeding-grounds upon the east and south portions of the State. They came literally in clouds, looking like the frost-clouds that drift along the horizon on a winter morning. They are devouring "every green thing," including shade-trees and even weeds, such as the "Jamestown weed" and wild hemp. The great body of them seemed to pass south, moving in dense masses during the 23d, 24th, and 25th, and will probably be heard from in Kansas and Missouri. I have suffered a total destruction of 60 acres of corn, as fine as I ever raised. The amount of damage in Nebraska is hard to determine. The small grain was harvested; corn and vegetables alone suffer. Taking into consideration the fact that we always overestimate a standing crop of corn, and are disposed to underestimate our losses, I think we shall be fortunate if the corn realizes one-third the anticipated yield. A few words upon the "parasite" delusion. The grasshoppers last year were to a great extent infested with the coral-like insects, but my conviction is that they are no more fatal to them than fleas are to a dog. This season I have failed to find any "parasites." At present no natural enemy appears to interfere with the festive progress of the locust through this fertile region. Many have concluded, and I am one of them, that for the present the locust is an "incident" to this locality, the solitary "drawback" to our enviable lot, which can be obviated in part by new methods of farming, but which can be altogether removed only by one of these unexplained and beneficent interpositions of Nature by which certain species are occasionally overwhelmed with destruction, and appear again only after a lapse of years. Warned by Mr. Riley's example, I will venture no prediction as to next year, but present indications are that our small grain will suffer early next summer, when the eggs now being deposited are hatched, but that the late corn will be unmolested, in consequence of the flight of the new brood to their natural home in the Northwest.

Another correspondent, Mrs. C. L. Nettleton, of Red Willow County, Nebraska, writes as follows to the New York Tribune:

Locust prospects is a subject of much anxious thought with us, and I am tempted to write of our experiences in this valley of the Republican River. I trust that efforts to secure a thorough investigation and abatement of the pest may be successful. It

seems to me a matter of national importance, as settlements must retrograde unless the locusts are checked. They came down upon us July 26–27, doing much damage, but left without consuming everything. August 5 they re-appeared in great numbers, looking in the distance like great clouds of smoke. Nearer and over our heads the air appeared to be filled with snow-flakes. Locusts were around, on us, and on everything, literally "covered the face of the earth." They began to come about 4 p. m., and the next day they had our fine field of corn stripped. It was like resisting fate to fight them. We tried smoking them, covered vines and portions of our garden with hay and blankets, giving the insignificant creatures a sort of hand-to-hand fight, in which they won by sheer force of numbers, and made us glad to retreat into the house. They brought with them an omnivorous appetite, eating things which they passed by in 1874—vines of melon, cucumber, squash, pumpkin, &c.

They took our tomatoes, potato-tops, indeed all our garden. They ate our strawberry-plants and young fruit-trees; also, our few flowers. Not content with such a varied bill of fare, they forced their way into the house and ate the house-plants. They staid with us five days, until they had ended their large meal by finishing up everything. Then while we were planning to catch them and barrel them up to fatten our poultry and swine, a friendly (?) northwest wind carried them off. Owing to the drought the small grain was a failure; the locust harvested the remaining crops, leaving the farmer no reward for his toil. They have visited the country every year since the settlers have come in, but only in 1874 and 1876 doing serious injury. They have been by far the most numerous this year. It has been an extremely hot, dry season, the prevailing wind south, often hot as from a furnace, and undoubtedly the unusual season has had much to do with the unusual numbers of the locust. Farmers with their crops harvested are like Othello with his occupation gone. Many have lost faith in the country and are leaving in "prairie schooners." We are about 70 miles from the Union Pacific Railroad. Some turn toward the setting sun, others southward, and others still go, they scarcely know where, in search of employment. It seems like a "sorry" going off to seek one's fortune—a journey in which a supply of hope and enthusiasm is needed.

According to the Monthly Weather Review, grasshoppers were seen at Richmond, Nebr., flying north on July 2 and 3, and flying with the wind 26th, 27th, 29th, 30th and 31st. August 5, at North Platte, Lincoln County, entire corn-crop destroyed, and in Dawson County one-fourth of crop destroyed; came from Dawson County to Buffalo County. 10th, Clear Creek, flying southwest; 11th, northwest; arrived in immense numbers 18th, and remained rest of month. 11th, alighted in immense numbers at Fremont, Dodge County, and commenced in the corn; country near Elm Creek, Buffalo County, cleaned out; column moving in a northwest direction, not many miles wide. 12th, very thick at Columbus, Platte County; came down the valley from North Platte, doing but little damage. At Grand Island, Hall County, loss small. 13th to 26th, at Omaha, numerous at times, flying in all directions. 18th to 31st, at De Soto. 23d, at Lincoln, Lancaster County, in vast numbers, but not so numerous as in 1874; passing south and southeast in clouds; corn considerably damaged. 24th to 31st, at Plattsmouth. 25th, in York County; have left nothing but harvested grain. Plattsmouth, flying about, September 1 to 15. Richmond, flying north 4th and 6th, northeast 20th, northwest 21st. *York:* The grasshoppers have called on us again. They came down August 10, from the northeast, and staid two weeks to a day. August 24 they left, going southeast. They have eaten almost everything green, destroying all garden-vegetables and taking the leaves off the trees. The fruit-trees, such as apple, cherry, and plum, are leafing and blossoming again. The plum-trees have ripe fruit and blossoms, which is something I never heard of before. *Furnas:* Came down in dense clouds from the northeast, so thick as to darken the sun, having the appearance of vast clouds of smoke. Nothing of the kind has equaled this raid since the earliest history of the country. Some have laid eggs. We are compelled, as in 1874, to note an almost total destruction of corn and all late vegetables. *Knox:* Entirely destroyed the corn and garden products and the oats so badly that many fields were not reaped. *Osage:* Came August 24, and are still here.

Have taken potatoes, buckwheat, and beans clean; have injured corn about 15 per cent. and are still at work on it. Have deposited eggs in great quantities. They incline to travel southeast, but the wind is against them. *Cuming:* Came from Dakota August 4, staid about ten days, injured late corn and potatoes, beans, gardens, &c.; deposited many eggs, and have nearly all gone southward. Insects will destroy their eggs, and birds, quails, and prairie-chickens will eat their young when quite small in untold millions. In their matured state nothing can successfully cope with them save quails, prairie-chickens, and other insectivorous birds. *Dodge:* Swept down upon us from the great northwest August 10, bringing terror to the hearts of our people. They remained about two weeks and deposited eggs in immense numbers. Hops were entirely destroyed; fruit-trees are stripped of their leaves, and in some sections of the new growth of bark. But half the corn is left. *Webster:* Injured corn slightly. *Franklin:* Damaged corn 50 per cent. Have now all gone southwest. *Adams:* Have taken about half the corn and injured young trees 50 per cent. *Saunders:* have re-appeared since the last report. Corn, potatoes, and sorghum have been largely damaged; tobacco, buckwheat, and beans have been wholly and gardens mainly destroyed, and the earth is filled with eggs. *Seward:* Came from the north in immense quantities. They fed upon the corn and cultivated grapes, and destroyed 80 per cent. of the buckwheat. A few linger still in the south part of the county, traveling southwest. *Thayer:* Alighted about a week ago. Have injured corn very badly, and taken all the garden products. *Boone:* Came in large numbers August 3. Have destroyed all buckwheat, beans, and late corn; stripped the foliage from all young trees, and killed young fruit-trees. They staid about three weeks; have all gone south. *Lancaster:* Are eating everything. *Platte:* In their flight south visited our county on the 10th of August, and in consequence of adverse winds remained two weeks. They entirely ruined late corn, made general havoc of vegetables, and filled our land with eggs. *Wayne:* Alighted and commenced work August 6 and 10. Injured late corn 25 per cent., potatoes slightly; deposited their eggs, and left August 13. *Antelope:* Came from the north, August 5, in countless numbers, and swept late corn, buckwheat, potatoes and beans clean. *Richardson:* First appeared yesterday, August 30, in small numbers from the northwest. *Merrick:* Crops promising up to 10th of August, when the grasshoppers came with the wind from the north. The next day the wind changed, and continued rather strong from the south for a week. The hoppers had to stay on the ground and could not do much damage. On the 18th, the wind being from the northeast, they left, but toward evening a lot more came. On the 24th, all left for the south. Buckwheat, late beans, garden-vegetables, late potatoes, &c., are all a total loss. On the 17th some deposited eggs where the ground was bare. *Hall:* Large swarms appeared from the northwest August 10 at noon. Commenced depositing eggs on the 13th and 14th; on the 14th some left; still larger masses came in their stead, mostly from the northeast. Farmers generally tried to smoke them out, but most abandoned the effort after the third day. I protected my garden for ten days, but from the 11th to the 13th they piled in on me so fearfully that I could not keep them from stripping nearly every tree of its foliage. They have eaten about one-third of the apples and half the early with all the late corn. On the 23d and 24th they left in a southern direction, the wind being from the northwest.—(Monthly Agricultural Report, August and September, 1876.)

I have also the following notes on its appearance in Nebraska from

Mr. G. F. Dodge, of Glencoe, Nebr. As Mr. Dodge is an entomologist, his testimony is of increased value:

GLENCOE, NEBR., *February* 4, 1877.

DEAR SIR:

* * * * * * *

Since I have been here I have given more attention to the *Caloptenus spretus* than to all other insects together. The result of my observations has been that I have formed a theory of the cause of immigration of this insect, which differs radically from any yet put forth. My record of the insect's visitations runs like this:

In 1873, *C. spretus* came from the south in May; remained a week or ten days; deposited eggs in large quantity at this place. I came here August 7; the insects had then about all attained their wings. During their growth they had done much damage to crops, destroying all the oats and corn where they were abundant. The insects did not move until August 16, when the wind, which had been from the south continuously during the month, veered round into the northwest. They arose about noon, and all left. Others flew over, going south from that time until cold weather. Some eggs were deposited in the fall.

In 1874, a few came from the southwest May 30, but only a few. May 10 the eggs laid the fall before were hatching. They pupated about June 1, became *imagines* about June 20, and went south with northerly winds June 30. July 23 immense swarm alighted, coming from the northeast July 23; staid three days, and went south. I saw no eggs deposited. Others went south in August, September, and October as usual.

In 1875, they arrived in small quantity from southwest May 12; could be seen flying north whenever we had a south wind, but especially on and after June 16. On that date myriads came from the southeast, staid one night, and, the wind continuing favorable, went on in a northwesterly course. June 29 I first saw hoppers flying south. After that they could be seen flying either north or south, as the wind might be, until the 10th of July, after which date they only appeared in the air when the wind came from the north.

In 1876, a very few came from the southwest May 14; saw some depositing eggs about May 30. August 10 an immense swarm came from the northwest and staid a week. The day they departed the wind began to blow from the northwest, changed to north, and finally to northeast. The air was full of the hoppers all day. They always changed their course to go with the wind. They left the ground full of eggs. In these the embryo was formed at least a month before the ground froze. By bringing eggs to the house and putting them in a warm place I have hatched them in seven days. Some of the same that were not kept so warm, but merely kept from frost and in the sun, have lain three weeks and do not hatch.

I think the above notes substantiate my position, which is that *spretus* is *double brooded*, rearing the first brood in the south, the second in the north; and that it migrates for this purpose, and not from hunger, as Riley asserts. I believe also that they are natives of the plains, and will always overrun this part of the country when a north or southwest wind drives them a little off their true north and south course during their period of migration. I do not believe that they are more liable to attacks of parasites here than elsewhere, and, indeed, think it not improbable that their present rate of increase is due to their having found more nutritious food in the cereals upon which they have fed for a few years past than they have known in the prairie-grass. A parallel case is that of the *Doryphora 10-lineata*, which increased with such rapidity upon the cultivated crops of the East.

In the Rocky Mountains this grasshopper follows the same plan of migration with the first favorable wind after they get wings, as I have observed here. They were abundant in Montana this year, and at my request an intelligent miner took notes of their habits, which he has transmitted to me. My observations show that as a rule all obtaining wings prior to June 20 will fly north; those becoming *imagines* after that date will fly south. This date might vary as the spring was late or early.

* * * * * * *

Hoping to make myself useful next season, I remain, yours, truly,

G. M. DODGE.

The following statement regarding the appearance of the locust, in Buffalo County, Nebraska, and the theory of its northwest origin, are worthy of preservation in this Report:

BUFFALO COUNTY, NEBRASKA, *August* 8, 1876.

EDITORS COUNTRY GENTLEMAN: The all-prevailing theme, the all-absorbing topic on all occasions, is the grasshoppers. Their devastation in almost the entire portion of Western Nebraska is not only general but terrible. Their numbers are almost as countless as the sands on the sea-shore; their powers of destruction seem to exceed

that of the race that visited us in 1874 by fourfold. Now they are eating every green thing—the leaves from the trees, the grass in the ravines, the forest-trees along the Loup and Wood Rivers, corn, potatoes, tomatoes, everything. Our corn-fields to-day present the appearance of so many acres of naked bean-poles. They have covered the city of Kearney all over; in the houses; on the sidewalks; they even inspect the fine store-rooms of our dry-goods and grocery men; in fact I do not believe there is a square inch of territory in Buffalo County that has not been searched by these marauders. The first indication of their approach was on Friday, July 28. Almost from the first we saw they were an entirely new generation. They had huge appetites, and at once proceeded to find the sweetest and tenderest ears of corn in our fields. They poked their noses head downward, tail upward, into the very heart of our small cabbages. They almost dug up our onions by the roots. They ate up our melon-vines and then partook greedily of the unripe fruit. The wind remained in the south from July 28 till August 5, when about noon it suddenly changed to north-northeast. In less than twenty minutes, every hopper of this advanced guard wended their way southward. How happy we were! Vain delusion. At 4 p. m. the east, the north, the west, presented the appearance of dense clouds of smoke, like that of burning prairies. We saw it full 20 miles away. We gazed in wonder. The clouds approached, the air swarmed with hoppers. We could hear the sound of their wings. They were so close together, so dense, that they darkened the sun similar to an eclipse at midday. The first cloud passed. At 5 p. m. another, more dense, more terrible, more numerous passed over head, leaving a few stragglers to search for something to stay their stomachs. We thought by this time, surely the army had passed, but about 6 p. m. another writhing, moving mass was seen approaching. On its arrival just over our heads, down they came, like huge flakes of snow, so thick that the ground was in many places invisible. Here they remained till the next morning, scattered over the prairies. About 9 a. m. they began gathering in endless swarms into our corn-fields, and by 1 p. m. every leaf, ear, and in many places the stalks, were eaten, digested, and part of the army on their way southwest to hunt for and despoil new fields. About this time the wind changed to southeast, then veered to the south, and from that time until this writing (Tuesday evening, August 8) the hoppers are with us supping, as a last resort, on purslane, tumble-weeds, and even thistles. They will undoubtedly remain in this section until the wind changes again into the north. So much for the appearance of and destruction caused by these foes of the agriculturist. We see our entire season's work, except one-third of the crop of wheat, melt away almost in a moment, and we are helpless.

The query in my mind, as well as in the minds of many of my suffering neighbors, is where these hoppers come from. In carefully watching their progress two years ago, as well as this season, I am satisfied in my own mind that there is a slope of country to the north or northwest of Minnesota, in the British possessions, where these insects are indigenous; that in extremely dry seasons, like the present, the eggs deposited last fall hatch in such endless quantities that the locusts are forced to migrate; while in extremely wet springs, with heavy falls of snow or late frosts, in the territory where they originate, many of the infant progeny are destroyed. In July, 1874 vast numbers, it will be remembered, descended and spread over almost the entire territory west of the Missouri River. They deposited eggs in Kansas and Missouri, and in the spring of 1875, caused wide destruction in the southeast part of this State, the northeast part of Kansas and the northwest part of Missouri. This progeny seems to have been annihilated—various influences during the summer of 1875 causing them to be without the power of propagating their species. Now this season (1876), if I am not mistaken, an entire new generation can be traced from the Red River country of the north, through Western Minnesota, Southwestern Dakota, thus far into Western Nebraska. If I am correct in these observations, then, whenever our springs are dry, with but little snow or rain during the winter, followed by dry weather in June and July, we may expect grasshoppers in just such endless quantities as we have seen twice during the past four years. Whenever the winter, spring, and summer are just the opposite of the foregoing, then we will be comparatively free from these pests and our crops plenteous. I am satisfied in my own mind on the above points; and I believe further that the territory wherein these insects are indigenous, is not so large as to be beyond the control of a power, with a purse long enough to procure the necessary labor, to work the destruction of young locusts and eggs before they can make such descents upon us. Only the strong arm of Government, however, can wield this power; and sooner or later it must intervene, or this entire western territory, with its riches lying beneath the grassy sod, must be abandoned for all agricultural purposes.

Our corn, potatoes, and all our vegetable crops have already disappeared. Many of our wheat-fields were not cut at all; others yield all the way from two to twenty bushels per acre, according to location. There is as a general thing south of the Platte River a very large crop of small grain, which has been harvested, while the corn, potatoes, and vegetables are fine as they were last season. North of the Platte, throughout a portion of Hall County, all of Buffalo and Dawson Counties, the drought has been

severe and continuous since the last of March. We have had a few showers; but, except immediately along Platte River, these showers have rarely been of length enough to wet the ground more than to the depth of one inch. I may say, I think, with perfect safety, that for two years past we have not had rain enough to saturate the ground to the depth of 3 feet, while the fall of snow in the winter season has been very light. In this connection it should be remembered that in digging wells we find the soil dry as an ash-heap, almost from the top of the ground to the water-line on a level with low water in our rivers, or on the divides to a depth of sometimes 140 to 60 feet. It will be easy to understand the effect of continual dry weather upon our crops and pockets.

I do not think that any of my near neighbors will complain or take me to task if I again say that a poor man with a family, and but little means, should think twice before attempting to make a home especially in Western Nebraska, for by the time this is in print no less than eight out of twelve families living near to the north and west of me will be on the way to Iowa and Missouri—some having already departed for the Pacific slope. Some are selling their claims and all their stock for less than half their value, while others are leaving their claims to hoppers, and to settlers desiring to try their luck. Many of my readers may think over in their minds the old adage that a "rolling stone gathers no moss," but permit me to ask a question: How much moss can a stone gather when visited continuously by drought, bugs, and hoppers?

Generally speaking, you can rarely find a more energetic race of men, both English and German, than those who are leaving us now. Some of them came here with money. They have sunk it all in their farms, in efforts to live and make a living, only to see it all swept away in a day. There seems at present to be no remedy except stock-raising, and this cannot be done in this country without capital. To commence with a cow or two, and live, clothe a family and school them, is almost an impossibility. One of my neighbors declares that he "will not live in a country where he has got to die in debt to his stomach."

F. N. C.

THE LOCUST IN KANSAS IN 1876.

In Kansas the locust visitation was less formidable and did not extend so far east as in 1875, as may be seen by the following letter of Professor Snow, dated University of Kansas, Lawrence, Kans., October 4, 1876:

Your postal card reached me upon my return from Colorado, and I have delayed replying to your inquiries because I wanted to know what the locust was going to do for us before writing about him. I came through Kansas from Colorado (Denver) on the 5th and 6th September. *Caloptenus spretus* at that time extended about 100 miles east of the mountains, last of which point no trace of it was to be seen during daylight on the 5th. Next morning we struck locusts in small numbers at Brookville (Saline County), 180 miles west of Kansas City; in full force at Salina, 12 miles farther east; and found the east front of this line 4 miles west of Abilene, in Dickinson County, and about 150 miles west of Kansas City. Observing and inquiring at the stations in this 30-mile belt, I invariably learned that the flight of the locust was from the *north* and not from the *west* as two years ago (in 1874).

Four weeks have now passed and the locust has not yet reached Lawrence, its eastern line being about 20 miles west of Lawrence, only about 100 miles farther east than it was four weeks ago. This eastern line extends across the State from north to south, the entire State west of this line having been visited. In many places the pest has come in immense numbers, while in many other places there has been but a light sprinkling. Little damage has been done thus far, almost none at all in comparison with two years ago, it being so late in the season that the crops of this year were secure. The fall-wheat, however, has been very generally eaten down, but has come up again when *drilled* after the departure of the hordes which remain but a few days in a place. Wheat sown broadcast has been generally killed, having been eaten down to the kernel. The great danger to be feared now is the spring-hatching of the eggs which have been deposited in varying abundance in the eastern part of the region visited. It is agreed on all hands that the present visitation is far less numerous than two years ago. The locusts are everywhere reported to be heavily parasitized by the red mite and the Tachina fly. Can it be that these hordes are the "spring-hatch" from Iowa, Minnesota, and Wyoming? While in the South Park in July, I found great numbers of young *spretus* along the streams from the mountain-sides. When on the summit of Pike's Peak July 28 and 29, the winged results were flying due east as high up in the air as the eye could reach. They did not descend upon us at Manitou until the 12th of August.

We quote also from the Monthly Weather Review:

Near Dodge City, April 30, the ground was thickly covered with the young. August 22 to 31, Dodge City, numerous and very destructive, causing entire loss of crops in many sections; 24th, Ellenwood, came from north and northeast; 29th, southwest; 31st, northeast and west. Fort Wallace, flying southwest 19th, north 23d, settling 24th; 31st, Atlanta, came in large numbers, injured fall-wheat, late corn, and gardens; also flying southeast. In September, Dodge City, abundant, flying north 2d and 4th, east 8th and 9th; less abundant 6th and 7th. In October they were reported "numerous and destructive at times during the month at Le Roy and Baxter Springs; reported nearly all gone at Creswell, 19th, and Council Grove 31st. In November grasshoppers were killed on the 14th by the snow-fall. *Brown:* The grasshoppers have destroyed about all the wheat, rye, and timothy that have come up, and will doubtless destroy all that has been sowed. The farmers have stopped sowing, owing to their presence. *Sedgwick:* The grasshoppers alighted on the 1st of September, not in such numbers as two years ago, but enough to eat all the young wheat and rye as fast as it appears. Many of the farmers are still sowing wheat. *Bourbon:* The grasshoppers appeared on the 28th of September, and are eating the wheat clean as they go. *Cowley:* The grasshoppers have taken all the early-sown wheat and rye, and they are still with us. They keep us from sowing wheat. *Douglas:* Owing to the prospect of another grasshopper raid but little wheat was sown until within two weeks. The early-sown looks fine. *Woodson:* Grasshoppers came on the 9th of September by the million, and have destroyed all the early-sown grain. *Chase:* The grasshoppers came September 9, and the wheat that had been sown is all destroyed. *Lyon:* The fall sowing of wheat and rye has all been devoured by the grasshoppers. *Osage:* On the 9th, 10th, and 11th of September the wind from the northwest brought billions of grasshoppers, and consequently all the small grain is a total loss. *Reno:* The farmers are still busy in sowing wheat; some ground is being planted for the third time; only about half the area will be sown that would have been if the grasshoppers had not come; all the early-sown was entirely killed. *Shawnee:* The grasshoppers have eaten about half of the wheat and rye sown; the farmers are sowing their grains over again. *Washington:* The farmers are now busy in sowing fall-grain; we do not fear the grasshoppers in the spring, for the farmers will plow all they can this fall and winter, with the expectation of killing the grasshoppers in the egg. *Saline:* All wheat sown before the grasshoppers came has been destroyed by them. Some farmers have lost 200 acres, and one has lost 1,200. *Mitchell:* Came from the north, the wind being from that direction, August 23. Began to come down at 9 in the morning, and by night the ground was literally covered with them. They commence to go into the crops as soon as the sun goes down, on the south and west sides of the field. They are eating the blades off the corn, which is loaded with them, and the leaves off the trees. Early corn is now quite hard and will not be seriously injured. *Pawnee:* Made their appearance August 24, coming from the northwest. Most of them passed over, but a few alighted, owing to the changing of the wind to the south. Corn is too far advanced to be injured, and they are not doing much harm except to gardens. *Washington:* Visited us August 24, at 11 o'clock in the morning, coming from the northwest. So far they have alighted on about half of the county. They are stripping the blades from the corn, but appear to pay more attention to the process of incubation than to feeding. The prevalence of a south wind has kept them here until to-day (August 31). The north wind is now blowing, and they are filling the air by the million, passing rapidly to the northwest. They have deposited no eggs, and done little damage. *Ellis:* A visitation from grasshoppers last week ruined the late corn, and injured all somewhat. *Reno:* Commenced to alight August 31, at 11 in the morning, and are eating everything green. At 2 p. m. to-day, September 1, many of them flew away. They have almost ruined the late crops, especially corn. *Norton:* Have ruined the corn-crops. *Barton:* Appeared August 24 from the north in vast swarms, and have destroyed all late corn and potatoes, beans, turnips, &c., and the wheat that was up. To-day, August 31, with a strong north wind, they are going south. They have made no deposit of eggs. *Graham:* Descended in clouds and remained five days, destroying our corn, buckwheat, turnips, and gardens. *Rice:* Have returned for the last week in as great numbers as two years ago. The corn, except the late-sod corn, which they have riddled, was out of their way. They have mostly left. *Republic:* Filled the air August 24, when corn-fields were ravaged and gardens disappeared in an afternoon. We have the assurance that we shall raise our own grasshoppers next year, for initiatory steps are being taken to give us a large supply. *Butler:* On the last day of August I was in Wichita, Sedgwick County. About 4 o'clock p. m., a very large column of grasshoppers passed over. In their flight they made a noise like the rattling of a train of cars. I do not know how far the column extended west, but it extended more than twelve miles east of Wichita. Their flight was toward the south. Although the main part passed over, enough stragglers were left in the valley of the Arkansas to eat every vestige of green wheat as fast as it came out of the ground. Some few appeared as far east as El Dorado, but no damage worthy of mention has yet been done in Butler County.—(Monthly Agricultural Report.)

THE LOCUST IN IOWA IN 1876.

In Iowa, Governor Kirkwood states that "the eggs have been laid in large quantities this season in a wide area of the western portion of the State, and the fear was expressed that they might come another season in swarms. In Northwestern Iowa the people are very careful to preserve the prairies from burning this fall, so that they may destroy the young in the spring." (Proceedings conference of governors, etc.) Concerning the grasshopper invasion of 1876, I extract the following data from the Monthly Weather Review, August 6: "Appeared at Storm Lake, Cherokee, and Sioux City, column extending to Lower Dakota and Lamar's, Mo.; at Fonda, Pocahontas County, damage slight; 25th at Unionville, Appanoose County, flying in large clouds at a high elevation, and Des Moines, Polk County, flying toward the Missouri in immense numbers. None have yet alighted in Central Iowa." *Crawford:* Injured corn 33 per cent. *Clay:* Have nearly ruined our crops. *Harrison:* Made their appearance on the 17th of August; reduced an extra corn-crop to an average; destroyed buckwheat and gardens; are injuring fruit and depositing their eggs over the whole country. *Humboldt:* Have injured corn and nearly ruined buckwheat and beans. *Calhoun:* Have trimmed around corn-fields and so injured buckwheat that it will not be cut. *Cherokee:* Came with a north wind, on the 6th of August; staid two weeks, and have deposited eggs to some extent; they damaged wheat slightly and a very heavy corn-crop at least 25 per cent. *Sioux:* Reduced corn to 40, wheat and barley to 70, oats to 80, and potatoes to 10. *Greene:* Swarm of grasshoppers are destroying the country. *Montgomery:* Came August 25; have done no injury as yet, except in a few gardens. They seem uneasy, as if they desired to leave. The wind has only been favorable for them one day since their arrival. *Audubon:* Came in clouds on the 24th of August; are doing some damage on the corn and filling the ground with eggs. *Guthrie:* Coming on us during the last week by millions; looks as if they intended to stay with us, and if they do, our crops will suffer greatly. *Pottawattamie:* Made their appearance in strong force on the 23d of August; have done considerable damage, and are laying eggs in large quantities. *Pocahontas:* Have come and gone again without doing much damage, except to gardens. *Sac:* The red-legged grasshoppers came about the 15th of August in such numbers as to materially injure our growing crops.—(Monthly Agricultural Report, August and September, 1876.)

"The Hamilton (Iowa) Freeman states that a gentleman, on examining the ground on which the insects had deposited their eggs, found 52 deposits in 4 square inches, or 13 per inch. The eggs in each deposit varied between 17 and 34, averaging about 25 to the cocoon. If these all hatched there would be 325 grasshoppers on each square inch. But most of the eggs were addled by the warm weather subsequent to their deposit. It is proposed to destroy them by burning over the prairies. In Woodbury, Iowa, the insects greatly injured the potato crop."—(Monthly Agricultural Report, November and December.)

THE LOCUST IN MINNESOTA IN 1876.

In Minnesota the eggs hatched out at Breckenridge May 23. In June the grasshoppers were infested by a "red-fly parasite," mite. In July, numerous at Breckenridge, 10th, 11th, and 12th; left, going southeast, 13th; appeared again 19th and 23d. In August, Breckenridge, swarms seen on 1st; very destructive 3d; flying and depositing

eggs 6th to 12th; in the western counties, wheat, corn, oats, and barley have suffered severely. In September, Breckenridge, Minn., flying south, 26th. *Jackson:* Are here yet; it is a hard matter to estimate the damages done by them. *Meeker:* Will injure the wheat in a few places. *Nicollet:* Are destroying the crops and depositing their eggs. *Nobles:* Came upon us just as the earliest grains were ready to harvest; wheat, corn, and timothy are very badly damaged, and other crops totally destroyed. They have laid eggs for a crop next year. *Pope:* The prospect of uncommonly good crops was very fine until about two weeks ago, when the grasshoppers came. Though they did incalculable injury, yet they did not stay long enough to effect a total destruction of crops. The air was filled with the pest, clouding the sun. They did not seem to design utter destruction of vegetation, but rather to leave their progeny. Eggs were laid all over the region. This work done, they rose on favoring winds and went southeast. Their stay on an average was about one week—in some places only four days; in others ten. *Redwood:* Damaged all the crops; the vines of beans and potatoes have been almost wholly eaten up and the foliage of fruit and certain forest-trees almost wholly stripped off. *Sibley:* In eight townships the crops have suffered severely from grasshoppers. *Stearns:* The advance-guard came on the 22d of July; the main army appeared the next day about 11 a. m., and by 4 p. m. every bush, flower, tree, shrub, fence, and field was literally covered with them. They are still with us and are depositing their eggs. *Stevens:* There would have been a full average of all crops, and perhaps more, had not the grasshoppers visited this county. *Todd:* The grasshoppers struck us the 19th of July, and have destroyed at least 67 per cent. of the crops of this county. As near as I can find out, the column is about 17 miles wide. They came in from the west by north. One of the finest crops we have had for ten or twelve years is destroyed. There is barely enough left to pay for reaping. Yesterday I cut barley that should have yielded 58 bushels per acre, and I will scarcely get 5. The heads are cut off and lying on the ground. *Watonwan:* Have destroyed the wheat-crops of the county. *Yellow Medicine:* In the counties Renville, Chippewa, and Swift, and parts of Kandiyohi and Yellow Medicine oats and barley are a complete failure on account of the grasshoppers. *Blue Earth:* The western towns are alive with grasshoppers, but they have come rather late to seriously injure wheat or oats. *McLeod:* Came from the northeast about the middle of July, and spread nearly over the whole county; have injured oats, barley, and late corn considerably and wheat to some extent, and have deposited many eggs. Some are reported as hatching and others as being destroyed by a worm or insect, but millions apparently will be left to hatch next spring. *Yellow Medicine:* Grasshoppers and dry weather have nearly ruined the corn crop and taken nearly all the oats. Half of the State is covered with grasshoppers. *Redwood:* Grasshoppers and drought have destroyed the crops this year more than ever before. *Swift:* Have done a great deal of damage; they commenced depredations about the 5th of July; there have been three or four swarms; they are now mostly gone, but have left their eggs in great numbers. *Faribault:* Injured corn 10 per cent., potatoes 50 per cent., and nearly destroyed beans. About the 15th of August they lit down on us from the northwest in countless numbers. They were about eight days in passing over the county and seeding it with eggs to such an extent as to destroy all hopes of crops for the coming year. *Meeker:* Destroyed nearly all the beans. *Nicollet:* Came with the wind from the north and west, and went south and west. Of cereals they cut the oats most; destroyed much of the corn and po-

tatoes and garden stuff. They have been depositing their eggs for the last two months. *Brown:* Reduced corn, wheat, and rye to 25; oats, barley, and buckwheat to 10. *Blue Earth:* Injured the corn somewhat and ruined beans. The county is literally filled with their eggs. Some of the eggs are being eaten by a small worm or maggot and some by a small red bug. *Nobles:* A small amount of corn and wheat escaped the grasshoppers; other crops are almost a total loss. *Stevens:* Have cut down our crops fearfully within the past month. *Todd:* Are all over the county; there is scarcely a foot of prairie or timber land on which eggs cannot be found. *Stearns:* Overrun the county and deposited millions of eggs. *Rock:* Everything was favorable for excessive crops when the grasshoppers came. They reduced wheat 30 per cent.; corn and oats 67; potatoes 75, and ruined beans.—(Monthly Agricultural Report, August and September, 1876.)

Further particulars regarding the locust invasions of Minnesota I extract and condense from a valuable "Report on the Rocky Mountain locust for 1876," by Allen Whitman:

Contrary to what was stated by Mr. A. S. Taylor, there was no locust invasion of Minnesota in 1855, but "late in July, 1856, invading swarms came from the northwest into the Upper Mississ ppi Valley, and gradually spread along the river during the season, much the same as they have done in the past summer [1876], and reaching nearly the same limits." * * * Again, in 1864, swarms appeared early in July, along the Upper Minnesota River, and spread eastward gradually during the season, and reached about as far east as in 1874, *i. e.*, to the third tier of towns in Le Sueur County. Scattering swarms also visited Manitoba in the same year, and probably some portions of these reached Northwest Minnesota, for we hear of slight appearances of them in the Red River and the Sauk Valleys in 1864 and 1865. But the greater portion of the injury was done in the Minnesota Valley, and was followed by a general departure to the southwest in 1865. * * * * It seems very likely that the swarms which entered Minnesota in 1864 were hatched at no great distance, and were the offspring of swarms that had alighted in Eastern Dakota in the preceding year. This may, perhaps, be inferred from the following letter of the Rev. S. R. Riggs, missionary at the Sisseton Indian agency, dated September 9, 1875:

"In 1863, it will be remembered that on General Sibley's expedition to the Missouri we met with the *ravages* of the grasshoppers in various parts of Dakota, particularly, as I remember, near Skunk Lake (in Minnehaha County), where the large grass had been eaten to the bare stalks, and our animals fared badly. In 1865 I visited a camp of Dakota scouts, near the 'Hole in the Mountain,' at the head of the Redwood. That was in the month of August. The valley of the Minnesota, clear out to the coteau, was so full of grasshoppers as to make it unpleasant traveling. For the next four years, I traveled every summer on the Missouri River, coming over to and from Minnesota. Every season I met with grasshoppers at some point on the east side of the Missouri. In 1867, and also in 1868, we found them near Fort Randall. In 1869, in August, we met them above Fort Sully, near Grand River. In all the cases they were only in small battalions, and appeared to have come there from other parts.

"Again, in 1871, slight and scattering swarms of locusts appeared in Stearns, Todd, Douglas, Pope, Otter Tail, Becker, and Polk Counties, and perhaps in others. * * * The invasion of 1873 was something unusual in its character from the earliness of its arrival, the direction from which it came, and from the fact that it was the beginning of a visitation which has been prolonged to the present time by what, judging from former years, would appear to be unusual circumstances. Each summer since 1873, instead of being the scene of a general departure of the hatching-swarms, as in former years, has seen portions of those swarms alighting but a few miles from where they were hatched (generally in the next range of counties, and sometimes in other parts of the same county), and depositing eggs for another brood. In addition to these, new swarms coming in from the northwest in 1874 and again in 1876 have added greatly to the area of devastations in both these years, and in the latter year to the area of egg-deposit."

The map appended to Mr. Whitman's report clearly shows the successive encroachments of the locusts in the State. The parents of those that have bred within the State since 1873 "reached the southwestern corner of the State about the 1st of June, 1873, brought by a wind that had been blowing freshly from the southwest for several days." The

progeny of these spread northward in 1874, but while fresh swarms entered the State in 1874 from the northwest, they did not, probably, add much to the stock of eggs deposited by the Minnesota brood, and Mr. Whitman thinks it "probable that the locusts which hatched in Minnesota last spring were, to a considerable extent, the descendants of the swarms which entered the State in 1873."

Mr. Whitman believes that in Minnesota there is not a return-flight of freshly-fledged locusts toward the Rocky Mountains, as shown by Mr. Riley and others to take place in Nebraska, Kansas, and Missouri. On the contrary, "the wind which sweep clear away the hatching-swarms of the more southern States carry our own but a few miles from their birthplace." He seems to incline to the belief that "some cause for the fact that portions of our swarms remain here to breed can be found in an early stage of egg-laying. While those observed late in summer to fly northwestward did not lay eggs, "on the other hand our own (Minnesota) stock were seen in 1875 to be laying within eight days after their flight commenced, and in the places where they first alighted, and during the past season the laying had already begun on the 3d of July, and by the 10th had become general in the western part of Nicollet County, within a few miles from their hatching-ground, and within two weeks from the time when the flying began. This early period of laying may be of itself a sufficient cause for portions of our swarms remaining here, while the less mature pass on."

From one year to another Mr. Whitman has noticed a natural decrease in the number of locusts breeding in Minnesota:

> Numbers of locusts have hatched out and have died without reproducing themselves. In this connection, the State of Minnesota has an advantage over more southerly regions, in the fact that we are situated nearer to the breeding-grounds of invading swarms. Of these, the earlier comers are more likely to pass over us before reaching the full period of their development, while the later comers are cut off by our earlier frosts; and of the eggs which are left with us, being deposited earlier in the season, more are likely to hatch in the fall and become harmless. On the other hand, the invaders are more likely to mass their forces in more southerly States, reach them in full maturity, and remain later in the season, while the eggs, being deposited later than ours, remain mostly unhatched until spring. These considerations enable us to understand why certain counties in Missouri, where the locust hatched in 1875, presented in May such a picture of devastation and desolation as Minnesota has never seen in all its locust experience.

The locust has also become shorter lived, and many were killed by the Tachina maggot, while of the invading swarms of the present year "large numbers of the bodies of the dead could be found in the fields early in September," and "large numbers remained alive until they were killed by frost, and even then died with eggs unlaid." Another effect of naturalization during the last four years, says Mr. Whitman, is that "while it has lost some portion of its inclination or its ability to migrate, it has also lost somewhat of its gregarious character." Indeed, had it not been for the new-comers in 1876, "next year would have seen the insects so few and so scattered as to be incapable of great damage, and they might become in a year or two as flitting and as unnoticeable as the red-legged locust that breeds with us every year." Mr. Whitman adds that, "in regard to changes in color and appearance, while the locusts which hatched in Minnesota last spring had when fully developed something of the darkness and dullness of old age, the brightness and fierceness of the fresh invaders was apparent to every one." Mr. Whitman concludes, and we think the facts reported by him bear out his statement: "Nothing is more certain than that we might, by general and continued effort, practically eradicate the offspring of almost any one year's invasion; nothing is more probable than that in almost

any season the whole body of our hatching-swarms might be utterly swept away from our midst by favorable winds; and, finally, if we may judge from the last four years, our breeding-swarms would decrease gradually from one year to another, and if not re-enforced from abroad would finally become so few and so scattered as to be harmless."

Mr. Whitman says that the facts observed in Minnesota do not substantiate the rule observed by Riley and others in Missouri, Kansas, Nebraska, &c., of a return migration in a northwest direction for the purpose of egg-laying, since they remain in part in the State and lay early in the season.

The origin of the swarms which entered Minnesota in 1874 and 1876 is not definitely known, but Mr. Whitman states that "it is probable that both in 1874 and 1876 the swarms that came into this State, at least in the earlier part of the season, were hatched in or near British America. This is to be inferred from the direction of their coming, the fact that we know of extensive hatching-grounds in British America in both these years, and that we know of no nearer hatching-ground."

The losses sustained by the State of Minnesota during the last four summers, ending with that of 1876, amounts to at least $8,000,000.

THE LOCUST IN DAKOTA IN 1876.

In Dakota, according to the Weather Signal Review, grasshoppers were active at Bismarck March 4; they were reported to have appeared on the prairies near Pembina in May, but few appeared at Pembina in June; in July they "first appeared at Pembina, flying northeast 8th and 9th, southeast 11th, 12th, 17th, 20th, and south 13th;" swarms of grasshoppers at Yankton 27th, 28th, 29th, 30th, and 31st; at Fort Sully, flying northwest and alighting 15th; northwest, 26th; numerous 16th, 27th, 28th, 29th, 30th." August 6 they "appeared in the extremesouth-eastern part of the State; 10th to 29th at Fort Sully, numerous; decreased during 30th and 31st. At Yankton during early part of month, destroying all the corn; about 10th began to depart and all gone in a few days. 26th, Bismarck, swarms flying southwest." They disappeared September 1 at Fort Sully.

Buffalo: The entire corn-crop has been eaten by the grasshoppers; wheat and oats, owing to the drought, ripened early, and were harvested in time to escape them. *Clay:* Have destroyed nearly all the corn and about half the wheat and oats. They are now depositing eggs. It is the worst grasshopper raid ever known. *Hanson:* We are again visited by the everlasting grasshopper. They have been with us for the last four days, and have left nothing of corn or buckwheat but the naked stalks. Oats are badly damaged; wheat and barley were nearly harvested before they came, and potatoes and sorghum were slighted by them, but they went through the gardens like a whirlwind. *Minnehaha:* Have made their appearance slightly, and have damaged some fields. *Richland:* Are now upon us. They came yesterday, August 1, a few days late. Gardens are all swept clean; not very much damage done to grain. *Stutsman:* Did but little damage except to oats, which they nearly destroyed. There are none here at present.—(Monthly Report of the Department of Agriculture, August and September, 1876.)

Governor Pennington states that he has never seen the young in Southern Dakota, and that the locusts fly over the southern portion of the Territory from the breeding-places in the northern. This view needs confirmation, we think.

THE LOCUST IN COLORADO IN 1876.

In Colorado the movements of the locust were closely observed by my friend, Mr. W. N. Byers, who has kindly sent me the following interesting account:

DENVER, COLO., *August* 26, 1876.

I think I reported to you the time and character of the grasshopper invasion and of their depositing eggs in this part of the country last year. In consequence of the latter the young ones hatched out in great numbers during the month of May. The farmers fought them actively and in most cases successfully. Those that hatched in plowed ground were destroyed by turning them under deeply at the proper time, or if the crop was already growing they were destroyed by the judicious use of fire, coal-tar, or kerosene. For this purpose they have a number of ingenious devices, and each agency is very effective in destroying the infantile grasshopper. Where they attempted to invade growing fields they were stopped by streams of water in or from the irrigating ditches. In these streams traps and screens were placed by which the insects were caught by the bushel, or a scum of kerosene was placed on the water, if standing or moving slowly, and this was equally fatal to them. The battle lasted but a short time, and almost every farmer who tried saved his crops. Early in the summer they disappeared, no one could tell how or where. The small-grain crop mainly matured with excellent yield, but the breadth of ground planted was reduced through fear of the insects.

Right in the midst of harvest, on the 3d of August, flying swarms began coming from the north and north-northeast. They alighted from day to day, but generally moved on the next day and continued their march across the State toward the south. After about a week their course changed to southwest, and they moved into the mountains, covered South Park, and at last accounts were reaching the headwaters of the South Arkansas and Rio Grande Rivers. On the first day of this new direction the flight was the most remarkable ever seen here by civilized people. During the whole day the air was literally thick with them as far as the eye could reach. But few came down. Thus they came and went for about three weeks. Toward the last nearly all had disappeared. They damaged corn and growing vegetables in Northern Colorado perhaps one-third, though the damage was very unequal—some places nearly total, and in others very slight, and some localities escaped altogether. In Southern Colorado the damage to similar crops was much greater; probably an average of two-thirds.

Two days ago a new swarm came and settled down in this neighborhood. I have no knowledge as to the extent of the country covered by them. They are pairing,* and as the weather is getting quite cool I do not think they will move much more. We are probably fated to another generation of them next year, but our farmers have succeeded so well in fighting them, and found it so much easier than they expected, that they snap their fingers at the thought of being eaten out by the young ones. But when they fly there is no power to resist them. This is the third year of the plague, and we are pretty sure of the fourth.

We think here that the first swarms came from the high plains of Wyoming, and the later ones from Western Dakota, Eastern Montana, and, perhaps, from British America. This judgment is based upon reports of their hatching in Wyoming, Dakota, and Montana. It would be a very simple matter to determine their movements exactly and predict their march with almost exact certainty.

Beside the information given in Mr. Byers's letter of August 1, I find it stated in the Colorado Farmer that in Larimer County they eat up the grain in the last of August, having been very destructive. In the same paper for September 7, M. W. D. Arnett gives the following account of their visitations:

To the Editor of the Farmer:

Perhaps a history of the visitation of the locust or grasshopper may be interesting in forming some conclusions as to what may be reasonably expected in coming seasons. In 1864, they came to my place August 26. Wheat and other similar grain was harvested; corn was full and getting ripe, but they eat it up almost entirely. They also deposited their eggs in vast numbers, which hatched out in 1865 and destroyed nearly all the crops. I saved my own by ditches, which was mostly oats. In this year, the young fry left as soon as fledged, going southwest. On August 5, 1865, an army of grasshoppers came and harvested the oats almost entire, leaving but a small amount of wheat and nothing else. In 1866 they came, I think, on the 9th of September, when small

* Farmers report that they are depositing eggs in some portions of the country.

grain and corn were out of the way, the latter being too dry for them to eat. They deposited a large amount of eggs in 1866, which done much damage in the spring of 1867. Now, the only difference in their visitations in '64, '65, and '66, between that of '74, '75, and '76, is this: In '74 they came thirty-five days sooner than in '64; in '75 they came ten or twelve days later than in '65; in '76 they came forty-two days earlier than in '66. From '67 to '74 we had but little losses from them. A light band occasionally done a little harm.

Their movements in all respects in '64, '65, and '66 have been precisely duplicated in '74, '75, and '76, and from this I conclude we will have six or seven years' rest now. Could we be informed definitely of where their eggs are deposited north of us, we would know just what to do to escape losses. Those south and west we need have no fears of. This dreadful plague must be stopped. Already it has prevented many from immigrating to the great and fertile West, and those here are looking and wondering where they can go to escape this plague, and if it was not for that adhesive power that holds people to their adopted homes, Colorado would soon be left to the grasshopper and red man.

The following notes are taken from the Monthly Weather Review of the Weather Signal Bureau, 1876: February 19, locusts hatched out at Golden; Estes Park, March 3. At Golden, eggs laid August 24, 1875, hatched out April 21, 1876. In June, in Colorado, were frequently attacked by the red mite. July 11, "a storm of grasshoppers at Pike's Peak." August 2, at Denver, "came from north in great numbers; very destructive 3d; continued numerous until 11th; had all left by 13th; from 22d to 28th flying in the air, but few alighting; diminished in number 29th to 31st; 3d, passed over Pueblo, going north; no damage. 5th, Golden, flying southeast about 6th to 13th, leaving 13th to 26th, returning from northwest 23d, and flying northwest 24th and 25th; 12th, near Denver, made a clean sweep of the mountain-ranches; came in dense, thick clouds, but have mostly moved away. 31st, Fort Garland, air filled, flying with the wind. September 8, at Fort Garland, they were seen flying northeast. At Golden, flying east-southeast 2d and 4th; flying northwest 6th; flying west and northwest 15th; flying east-southeast 23d; flying northwest 25th. Denver, more or less abundant, 1st to 24th. Flying northeast at Golden 2d. Summit of mountains near Denver covered with many thousand bushels of dead grasshoppers.

THE LOCUST IN WYOMING, UTAH, AND NEW MEXICO IN 1876.

In Wyoming, at Cheyenne, grasshoppers were reported alive May 14; abundant from the 7th to the 31st August; "flying southeast 1st, 10th, 24th; south, 6th; northwest, 8th. October 3d, a few grasshoppers were seen flying."

In Utah, September 28, at Salt Lake City, migrating; at Coalville, Utah, flying south 26th, 27th, 28th.

In New Mexico "they appeared June 19" (Monthly Weather Report); Taos, wheat half destroyed by grasshopper (Agricultural Report, July).

THE LOCUST IN MONTANA IN 1876.

Lieut. W. L. Carpenter, U. S. A., in a letter dated Camp Robinson, Nebraska, December 10, 1876, gives me the following notes and comments on the locust:

Upon the high plateau separating the valley of the Platte from the waters-shed of the Lower Yellowstone, swarms of newly-hatched grasshoppers were observed during the last of May, 1876. They appeared to exist in small colonies of a few square rods in extent. Several such were seen during the day, and the aggregate number of individuals must have been very large. They were just able to hop, and were consequently hatched on the ground where they were observed. About July 12, immense swarms appeared in Western Nebraska and devastated that region. These insects I believe to be the same observed in May, which upon reaching maturity moved eastward, instead

of going northward, as is usual with the spring broods hatched in the Missouri River Valley. No northward or return flight was noticed over the Big Horn region during the season of 1876.

About the last of July, 1876, the great flights from the northwest swarmed over the country along the eastern base of the Big Horn Mountains. They came in such numbers as to create a hazy atmosphere which was at first supposed to be due to prairie fires. During severals days they covered the earth and obscured the sun. Their line of flight was from the west of north, and in general appeared to conform to the contour of the mountain-range, following it to the southward and eastward. For some time after reaching the ground they seemed bewildered and inactive, but gradually recovered and commenced eating voraciously and pairing off. I did not, however, observe them lay eggs here. After remaining about a week they nearly all left one afternoon just as a stiff breeze was springing up from the northwest, their flight being still to the southeast. Of those which remained behind, about one-fourth appeared disabled for vigorous flight from the presence of the eggs of the parasitic mites which destroy so many; the little red oblong mites which were firmly attached to the under side of the wings, impeding them greatly and causing their ultimate destruction. Many other individuals had a sickly appearance, though I could discover nothing unusual affecting then excepting a general paleness of the body and wings and extreme weakness. These swarms appeared in Western Nebraska about the middle of August.

Upon leaving the Big Horn Mountain I passed in a northeasterly direction over the region drained by the Rose Bud, Tongue, Powder, and Yellowstone Rivers, and everywhere found evidence, in the condition of vegetation and the large quantity of "frass" on the ground, that a flight had also been here. I believe this to have been part of the great flight observed at the base of the Big Horn Mountains, and it consequently must have covered, at the same time, about 12,000 square miles of territory.

It would appear as though the great swarms, which are so destructive to eastern vegetation, follow in their eastward flight the general trend of our western mountains. Starting, as we suppose, from the Great Plains at the head of the Saskatchewan River, they would follow it down to the spurs of the Rocky Mountain chain, which curve to the southeastward and offer a continuous area of vegetation to sustain them in their journey. The Big Horn Mountains next come in view, and by their contour tend to place them well to the south by the time they reach the southern end.

The next objective point in their flight would be the Black Hills, which are densely timbered, and would naturally attract them from a distance. After leaving this latter region there are no prominent elevations to guide them in their flight, and they consequently follow the drainage of the Missouri Valley, stopping when the bright green fields of our farming communities are reached and suitable food obtained. The short prairie grasses at the season of their migratory flight have lost their freshness and begun to turn yellow. The prairies are consequently not attractive to them, and they only halt briefly for rest. But when the tall, luxuriant vegetation of the east is reached, they instinctively realize that they have arrived in a land of plenty, and accordingly leave their eggs where their young will find abundance of food upon hatching out.

In the southward flight of these great swarms, I believe that they never extend as far as Laramie Plains. The valley of the Upper North Platte appears to be the southern limit of their migration, although they cross the Platte farther to the eastward and overrun Eastern Colorado and Kansas. The Upper North Platte Valley is a region of very high winds and perhaps unsuited for this reason as a highway of travel; while the line of flight chosen by them is through a country unusually free from atmospheric disturbances.

The grasshoppers which visit that part of Colorado extending for some distance eastward of the mountains, I believe, take their flight from Utah, and travel nearly due east over the vast intervening mountain-ranges. The members of Professor Hayden's Geological Survey of Colorado observed them in 1873, on the summits of all the highest peaks, in vast numbers. I have never heard of a flight crossing the Union Pacific Railroad near Cheyenne, Wyo., and moving due south into Colorado along the mountain-range which here runs north and south. And this would have been observed if they entered Northern Colorado from the north instead of from the west. The main range of Colorado, from its great altitude, offers a formidable barrier to their eastward progress, causing myriads to perish from the cold which pervades these elevated regions.

If the country between the Big Horn Mountains and the Black Hills and the Upper Missouri and North Platte Rivers were a thickly-settled farming region, the great swarms on their eastward journey would stop here, and never reach the Lower Missouri Valley. The westward progress of civilization must ever decrease the amount of damage done to eastern agriculture; and finally when the entire West shall be settled, the cultivated fields will be extended over such a wide area that the swarms will be proportionately arrested and scattered, and the destruction of crops in any particular State be inconsiderable.

Under date of March 4, 1877, Lieutenant Carpenter writes me from Camp Robinson, Nebraska: "The warm weather has hatched out the eggs in Western Nebraska and a snow-storm has since destroyed the young."

In Montana the Monthly Weather Review reports locust as hatching out by millions in valleys about Virginia City. May 28 they were numerous throughout the Territory; 27th, began to fly. In July they were seen flying southwest 11th to 20th, and southeast 27th to 31st; much damage done in some localities. In August millions flying southeast 1st to 5th at Virginia City; decreased in numbers until 29th; no eggs deposited. According to the Monthly Agricultural Report for July, grasshoppers were abundant in July at Jefferson, and threatened to greatly reduce the wheat-crop. It should be noticed that the summer of 1876 was a hot and dry one throughout the West.

I quote further information regarding the locust in Montana from Mr. Whitman's report for 1876. Besides the region named in the article above quoted from the Winnipeg Standard, various parts of Montana are known to have been considerable hatching-grounds during the past spring. In the Bismarck Tribune of June 14 is found the following, which is quoted because it gives an idea not only of the place but of the nature of a breeding-ground:

IN THE FIELD, NEAR ROSEBUD BUTTES, *May* 29, 1876.

As we move westward the grazing improves, and here in the Little Missouri Valley the season is at least a month in advance of the season on the Missouri. This would be a splendid grazing region were the water good. The grass is heavy and nutritious, but the water is strongly impregnated with alkali. Millions of locusts are just now making their appearance in this region. Too young to fly or do much harm, in a few days, should the winds favor them, they will sweep down upon the defenseless agriculturists on the border, doing untold damage.

Officers who passed over the country between the Little Missouri and the Yellowstone Rivers during the spring state at various points in that region young locusts were found in immense numbers. Shortly before the 23d of July migrating swarms of locusts appeared in the vicinity of General Crook's camp; "myriads of grasshoppers filled the air, appearing like an immense drifting snow-storm, tending toward the southeast, and apparently taking advantage of a northwest wind to favor their flight to the same fields that they have effectually devastated for two consecutive seasons."—(Extract from a letter of July 23, quoted in the Pioneer Press and Tribune.)

HABITS OF THE LOCUST.

The following account of the habits of the locust, its mode and time of egg-laying, and its time of hatching, is compiled from the statements of others, as I have only been in the West during midsummer after the young had hatched and before the eggs were laid. Having, however, obtained the eggs of *C. spretus* from Iowa and Minnesota, and studied the habits of *Caloptenus femar-rubrum* of the East, so closely allied to *C. spretus*, and having observed the movements of *Œdipoda sordida* and *carolina* during the process of egg-laying, I can more intelligently describe the process in *spretus*. Indeed, all the different species of grasshoppers are very similar in their habits, nearly all laying their eggs in the ground, others (as in *Chloëatis*) inserting them in rotten wood. When about to lay her ripe eggs, the female selects a dry field, either in upland pasture or plowed lands, or even hard roadsides and paths. In the latter place they are more frequently observed; but from being interrupted when beginning their holes, they often leave smooth round holes, a little smaller than a lead pencil, and without any egg-sac. Immediately after

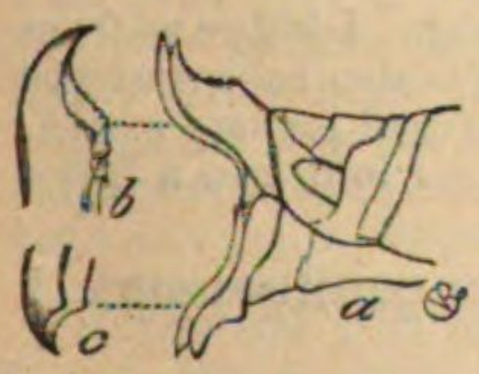

FIG. 1.—Rocky Mountain Locust. Egg-laying appendages of female. *a*, end of abdomen; *b*, upper; *c*, under hooks.

sexual union, the female (the males being distinguished from the other sex by their smaller size and blunt rounded hind bodies) proceeds to deposit her eggs. Selecting a suitable place, she forces her hind body or abdomen nearly or quite vertically downward into the earth for about an inch. During the process she opens and shuts the solid horny appendage (Fig. 1), forming four stout hooks, by means of which the soil is displaced, while a small bore is formed by the movements of the abdomen, which now elongates nearly double its original length, until the hole is an inch or more in depth. "Now, with hind legs hoisted straight above the back, and the shanks hugging more or less closely the thighs, she commences ovipositing, the eggs being voided in a pale glistening and glutinous fluid, which holds them together, and binds them into a long cylindrical pod, covered with particles of earth, which adhere to it. When fresh, the whole mass is soft and moist, but it soon acquires a firm consistency. It is often as long as the abdomen, and usually lies in a curved or slanting position." The figure from Dr. Riley's report, (Plate LXII, Fig. 1,) from whose account we have quoted, will give a good idea of the act of egg-laying or oviposition. Riley says that "the eggs which compose this mass are laid side by side to the number of from 30 to 100, according to size of mass."

Mr. Whitman, under date of February 18, 1877, further writes me regarding the breeding-habits of the locust in Minnesota:

In regard to this year, in addition to what I have written in my report, I found, September 7, a large number of females with from one to fifteen eggs in the abdomen, evidently ready to be deposited. Almost every female contained eggs. A few were found evidently totally exhausted of ova (or ovaries). All these had flown in from somewhere to the west late in August. So far as I have seen heretofore, the female, in July, before laying, has the abdomen largely distended with eggs. The female locust that I experimented upon was in such condition; then her abdomen decreased in size after laying; then increased again. But the females that I found in September, although having eggs in them, were not distended at all; in fact, there were some noticeable differences in appearance between those that flew away from us last July and those that flew in later in the season; and one difference was in the size of the body (or abdomen), and possibly this was what made the farmers say that the incomers were "smaller and not fully grown." I might go on to write considerably more in regard to the ovarian differences in appearance, but I don't know that it is worth while. I think I can sum it all up by saying that the locust which hatched in this State last spring could be very easily mistaken for the red-legged locust (as it appears about Saint Paul), while the new-comers were strikingly different in shape and somewhat in color. By the way, I have never been able to find any such thing as a red-legged locust down in the country where *spretus* was abundant. I have found a specimen or two of *spretus* in Saint Paul.

As for copulation, I think it takes place several times before laying. I judge so from what I have seen myself and what others have told me. I have been also told that the same female may receive two or more males. I had some two-striped locusts caged, and thought I could observe selection between males and females. I found in a large two-striped locust (in August) sixty-five eggs.

Regarding the breeding-habits of the locust while in confinement, I quote as follows from Mr. Whitman's report for 1876:

On the 25th of June I shut up in wire-gauze cages nine pupæ of the Rocky Mountain locust. The bottoms of the cages were filled with earth packed hard, and the insects appeared to thrive in confinement. By the 2d of July they had all become perfect insects. By the 8th of July they commenced coupling, and were seen repeating the act for several days. On the 15th and 16th, two of the females went through the form of depositing eggs, and I marked the place of deposit on the edge of the cage. The coupling was repeated again as before, until the 3d of August. At that date the coupling ended, and the locusts became almost inactive, and were seen to eat very rarely afterward.*

* The early part of this coupling-season was one of the greatest activity on the part of these insects. They dashed themselves against the wire of their cages as though all space would be too small to contain them. There would be a flash of the wings, extended and closed again in an instant, or that movement of the hind-legs known as "fiddling," which seemed to be a well-known signal between the male and female. In cages where several pairs were confined together, the male, while in the act of coupling, would repeat this movement if brushed against by another.

On the 14th of August one of the males died. The female died on the 9th of September, and was found to contain fourteen full-sized eggs; but I found, on examining the cage, that there was also a full-sized egg-cone where she had already appeared to deposit on the 15th of July. Of the rest of the Rocky Mountain locusts, the males were caged with some female red-legged locusts caught in my garden, and although the two species did not seem inclined to have much commerce with each other, I saw one pair coupling. These observations are very slight and imperfect, but are given for whatever they might be worth. That the male dies first may be inferred, not only by the above experiment, but from the fact that in September it was common to find many pairs coupled, of which the female was alive, but the male had died without releasing himself.

The time required from hatching till the wings are obtained averages about two months. The high and long flights characteristic to the species after the wings are acquired are seldom indulged, except when there is a fair wind.

Just as the mature insects fly, as a rule, in a southeasterly direction, so the young, soon after they hatch, manifest the same desire to move toward the southeast. They are most active in the heat of the day, but are perhaps more ravenous at night. They migrate short distances every clear day, but do not like to cross a stream unless they can jump it. If driven into water, however, they kick about, making considerable progress, and donot easily drown. Such, at least, are the habits of the young hatched in the Mississippi Valley, though it is very probable that in their native table-lands of the mountain region the migrating habit is not developed till they have acquired wings, and are forced from hunger to seek new quarters.

I copy the following letter from Mr. J. L. Cabot, dated Currie, Minn., July 20, 1875, which gives a good idea of the fecundity of the insect:

This is the third season that we have had hoppers. The first year they came on the 12th of June and deposited their eggs, and went away in four days, leaving the country almost totally cropless. The next season, 1874, they hatched in the last part of May, and staid here until about the 4th of July. They left the county totally stripped of all domestic vegetation, with the exception of about a tenth part of a crop of potatoes. The State furnished the county with seed-wheat this spring, and our land was all sown and planted again. Until the 4th of July crops bid fair for one of the largest yields ever known in the State. But on that day about noon the grasshoppers began to come down in such numbers that in some places they destroyed the crops in two days. They were very large ones, and left in two or three days, but had no sooner gone than other hordes of smaller ones came, and in double the number, and began to lay their eggs and leave. More came and took their places, and laid more eggs, and passed on southwest, rolling over the prairie like heavy clouds of mist on a foggy day. And still they come and go.

Another man and myself selected an average spot in a field and dug from a foot square 300 cones, each cone containing an average of 30 eggs, which would make 392,040,000 eggs to the acre.

We then caught about a pint of the grown hoppers and found it to contain 320 insects, which would make 20,480 to the bushel. And calculating each egg a hopper, we found that next spring when they hatch out we will have 19,000 bushels to the acre, and 3,200,000 to the quarter-section, or 14 quarts to the square foot. And still they are laying their eggs. But if they will go away to-day or to-morrow they will leave us enough to live on. I can't describe the feelings of the people. We think that if the State and General Government would help us to protect the grass on the prairies until next June, the hoppers might be exterminated by fire.

A few of the eggs hatch in the autumn. This has been noticed in Colorado by Mr. Byers,* and in Missouri by Professor Riley, who states that in this State "in most counties, even in the northern ones, some of the earlier eggs hatched, especially those laid on hill-sides and other high ground exposed to the rays of the sun. The young hoppers attained a size of one-fourth to one-half of an inch, and were active during the middle of the day, even into December. These young hoppers disappear and seek winter shelter; but it is doubtful whether many, if any, survive the winter." (Seventh report.) In his eighth report he says that in Kansas certain experiments made the following spring demon-

* In November a correspondent of the Colorado Farmer wrote that "the young locusts were hatching out in great numbers, and that the eggs deposited during the present season were so far advanced toward hatching that large numbers would be destroyed by frost during the winter and spring."—(Riley's Eighth Report.)

strated tne fact that a temperature of 2° degrees below zero was fatal to them.

The embryos evidently get their growth in the autumn and lie dormant until the spring before hatching. Mr. Whitman writes me under date of February 3, 1877, from Saint Paul, Minn., "We are interested here to know how near the eggs can reach hatching and still remain uninjured by feezing, and I have some eggs that were just taken from ground frozen solid, and were hatched after being kept moist and warm three days. I heard yesterday of a gentleman who started for Chicago with some eggs in his pocket and found them hatched on reaching that place."

In Missouri, the eggs mostly hatch in the middle of April and early in May, while some continue to hatch until June 1. The young acquire their wings in about seven weeks.—(Riley.)

In Kansas, the eggs hatched the first week in April, and the young first became winged May 28 and 29, and began to fly away then, until June 22.

The locusts leave Kansas, Nebraska, and Missouri about the middle of June, and are said to fly in a general northwestward course, while the fresh broods from the Rocky Mountains enter these States from about July 20 until the middle or last of September.

In Nebraska, they were fledged in 1874, about the 7th of June, and then began to fly away, and by the 6th of July they had about left the State. These dates will approximately apply to Minnesota and Iowa for the swarms from the Rocky Mountain region. In Iowa the grasshoppers in 1874 entered the State from the south and west about the 10th of June; these were the swarms from Kansas, or "probably deflected from their usual course by adverse winds." In Minnesota the young hatch in April and May, and get their wings and begin to depart about July 1, the departure becoming general about the 10th, and total by the end of August.

In Colorado, on the plains at the elevation of Denver, the eggs begin sometimes to hatch in March and continue doing so until early in May. The locusts acquire their wings and fly off about the first or middle of June. The swarms from the north and westward appear about the 20th of July, and continue to arrive until early in September. Among the foot-hills the eggs hatch in May, and at an elevation of 8,000 or 9,000 feet in June and even July the young in the subalpine elevations among the mountains in may cases perishing from the cold before acquiring wings. In Dakota, in 1874, they became winged during the first week in June and disappeared by the middle of July.

It is not generally known that the great powers of flight in the grasshopper as well as most other winged insects is due in part to the presence of large air-sacs. These sacs are expansions of the air-tubes which ramify throughout the interior of the body. They are found in the head and thorax, but are largest (especially in the honey-bee) in the base of the hind body. They do not occur in insects which simply crawl or walk. In the grasshoppers (*Acrydii*), most of the transverse anastomosing tracheæ in the abdomen have large air-reservoirs, greatly assisting in lightening the body and sustaining it in their long flights. It is from their development, probably, in the western locust (I have found them well developed in several eastern allied forms) that this insect is enabled to sail so lightly and easily for hours at a time in the air hundreds or even thousands of feet above the ground, as well as to spend days, perhaps, in its long flights during the migratory season.

The following valuable notes on the natural history of the grasshop-

per (*Caloptenus spretus*) have been kindly sent me by Prof. Samuel Aughey, of the University of Nebraska:

1. It is a mistake to suppose that the grasshoppers never fly at night. In August, 1866, I was camped on the Bow River, on an open prairie, in Cedar County, Nebraska. I was lying on a robe outside of the tent, the moon shining brightly. In the evening not a grasshopper could be seen or found. At 1 o'clock at night the wind shifted from the west to the north, and soon the atmosphere became perceptibly cooler. Suddenly grasshoppers commenced to drop, and continued to fall for nearly half an hour. In the morning the prairie was covered with them. I had a similar experience on two other occasions. On the Verdigris, a tributary of the Niobrara, and on the Upper Elkhorn in August, 1867. These experiences are a demonstration to me that they do sometimes, at least, fly on warm moonlight nights.

2. It appears doubtful to me whether these migrating grasshoppers ever move faster than the wind carries them. In August, 1867, when they were moving over Northern Nebraska, I climbed tall cottonwood trees, and let loose among the flying grasshoppers bits of cotton. These bunches of cotton moved or were carried forward as fast by the wind as the grasshoppers flew, and in the same direction. In June, 1875, I did the same thing from the cupola of the State University on four different days. When they were flying thickest the bits of cotton would keep even with them as far as they could be seen with a field-glass. And while these few experiments are not conclusive, it appears to me that, until some one sees them move faster than the wind, we have a right to presume that they do not. The only physical exertion, then, that the grasshoppers need to make in order to migrate is to raise themselves into the air and to keep suspended. The winds waft them into (to them) unknown regions. The height to which they often rise is very great. On the 18th of June, 1875, the column that passed over Lincoln, Nebr., was within 50 feet of being one mile in height. This I ascertained by trigonometrical determination.

3. It is probable that their constitutional vigor decays or declines in regions moister than their native habitats. I have attempted to ascertain this by various methods. One experiment was to attach the limbs of mature grasshoppers that were hatched in Nebraska to a delicate spring-balance, and ascertain in this way the degree of their physical strength. As they varied a great deal in strength, I averaged the strength of ten at a time. The following is an example of such an attempt, the first being taken from Nebraska, and the second from Northern Utah and Wyoming:

	Nebraska.	Utah.
The first grasshopper drew	1.50 ounces.	1.75 ounces.
The second grasshopper drew	1.50 ounces.	2.00 ounces.
The third grasshopper drew	1.25 ounces.	2.00 ounces.
The fourth grasshopper drew	1.75 ounces.	1.75 ounces.
The fifth grasshopper drew	1.50 ounces.	1.75 ounces.
The sixth grasshopper drew	1.75 ounces.	1.75 ounces.
The seventh grasshopper drew	1.75 ounces.	2.10 ounces.
The eighth grasshopper drew	1.50 ounces.	2.00 ounces.
The ninth grasshopper drew	2.00 ounces.	2.25 ounces.
The tenth grasshopper drew	1.50 ounces.	1.75 ounces.
	15.80 ounces.	18.80 ounces.

I have ten more tables of the same general character and results. Only in one did the two approach each other. The highest of the Nebraska columns came within half an ounce of the strength of the lowest of one set of ten from Wyoming. These tests were mostly made during July, 1875. I cannot think that the difference in strength between the Nebraska and Utah grasshoppers could have been accidental. I reached the same results by the experiment of ascertaining the length of time that the grasshoppers from the two localities could live without food. Omitting the columns of figures, the average result reached was that the Utah and Wyoming grasshoppers could live three and one-fourth days longer without food than those from Nebraska. Vivisection produced the same results. These and similar experiments satisfied me that away from their natural habitats the constitutional vigor of the grasshoppers becomes impaired, and that in a few generations they must tend to run out.

4. Confirmatory of the preceding conclusion is the following observation: As early as the spring of 1865 I noticed that probably not more than about 50 per cent. of the grasshopper-eggs that were laid the autumn previous hatched out. Almost daily from April till far into June I dug over some small portion of the ground where the eggs were thickest. Only an occasional *entire* nest of eggs hatched out. Some nests would hatch out in part and some not at all. Late in the season many entire nests of eggs could be found changed into an apparently gelatinous mass. In the spring of 1867 a still larger proportion of eggs seemed to be injured. Segmentation in many eggs had commenced in the fall and during the warm weather of February, and in many nests

the entire grasshopper had formed in the egg. The oscillations between thawing and freezing, wet and dry weather, seemed to have destroyed great numbers. The damage done to the eggs was greatest in low grounds. In both these years, also the spring of 1875 and the present spring (1876), there were an exceptionally large number of eggs in the ground. In digging over the spots where the most eggs seemed to be laid, the number ranged between 100 and 15,000 to the square foot. Isolated spots could always be found where the number was much greater. If, indeed, all would hatch out, no green thing could ever escape.

5. Among the curious things about their natural history is the following: Rainy days in some way are connected with the rapid development, or at least appearance, of the little red parasite, *Astoma gryllaria*. On June 1, 1875, the university grounds in Lincoln, Nebr., were covered with grasshoppers, and about two in a hundred contained these parasites, located mostly under or near the wings. On that day and night it rained, though it remained warm. Immediately after it cleared up the next day three out of every four grasshoppers were full of these parasites. Twice I have known this to occur. The cause or connection between the rain and the development of these parasites I have not ascertained.

The power of adaptation to varying circumstances which this migratory grasshopper seems to have is simply wonderful. Perhaps naturalists, in studying them, have been overhasty in drawing conclusions from a narrow range of facts. As to myself, after watching and experimenting for so long a time, I am not so sure that I understand them as I was ten years ago.

As an example of how high the grasshoppers may fly and the enormous number comprising a swarm, I quote the following statement from the signal-service observer station at Fort Sully:

June 15. [Direction of wind, as ascertained by the records: 6 a. m. to 7 a. m., northeast; then east till 10 a. m.; then south till 3 p. m.; southeast remainder of day.] Several days previous to this date had been hearing of the approach of locusts along the line of telegraph from Omaha, upward, to northwest; and at 4 p. m. of the 14th the operator at Fort Thompson (85 miles south, 25° east from Fort Sully) reported their advance flying northwest and northwardly. At noon a large cloud of the insects passed over until night, when they were no longer visible. Roughly estimated, the swarm may have been about 50 miles long, 25 wide, and one-quarter to one-half mile in height. A hail-storm the following day may have dispersed them.

June 23. [Direction of wind: 6 a. m., southeast; 7 a. m., southeast; 10 a. m., southeast; 2 and 3 p. m., east; rest of the day calm.] Large flights of locusts passing over during the morning, going north and northwest, at an estimated elevation of about 50 feet to as high as they were visible with field-glasses, possibly a mile; none alighting. This swarm, as near as could be ascertained by telegraph at the time, came from the Minnesota infested region, along the line of the Sioux City and Saint Paul Railroad, in a continuous cloud, probably 1,000 miles long from east to west, and 500 miles from north to south. How much farther north of this post unascertained, and not conjectured.—(Riley's Eighth Report.)

At Virginia City, in Southwestern Montana, the weather-signal observer states that "the locusts were thickest on July 20 and 21, giving the sun a hazy appearance. These 'emigrant' locusts came from the plains of Dakota, and were here, the largest bodies on the above-mentioned days, at least half a mile in thickness, and, as I learn from reliable authority, they presented an unbroken width of 20 miles, being even more numerous on the wings than here near the center."

In Indian Territory and Northern Texas they become winged, and migrate during the second and third weeks of May.

Habits of the young.—The Rocky Mountain locust casts its skin, or molts, five times after hatching. The figure (Fig. 4, Plate LXII) from Mr. Riley's eighth report graphically illustrates the process of molting. It should be borne in mind that the locust, like all grasshoppers, is born without wings, and during this period is called the *larva*. Soon the wings begin to grow, appearing as little pads (Fig. 4, *a*.) When these appear it is called a *pupa*, while the winged adult is the *imago*. When the larva is about to molt, the skin, which had become too small for it, splits open on the back of the head and thorax, and the larva withdraws itself through the rent, the body at first soft and flabby. With

each molt the wings, at first very small, increase in size. Mr. Riley describes minutely the molt of the pupa into the fully-winged state.

When about to acquire wings the pupa crawls up some post, weed, grass-stalk, or other object, and clutches such object securely by the hind feet, which are drawn up under the body. In doing so the favorite position is with the head downward, though this is by no means essential. Remaining motionless for several hours in this position, with antennæ drawn down over the face, and the whole aspect betokening helplessness, the thorax, especially between the wing-pads, is noticed to swell. Presently the skin along this swollen portion splits right along the middle of the head and thorax, starting by a transverse-curved suture between the eyes and ending at the base of the abdomen. Let us now imagine that we are watching one from the moment of this splitting, and when it presents the appearance of Fig. 4, *a*, Plate LXII. As soon as the skin is split the soft and white fore-body and head swell and gradually extrude more and more by a series of muscular contortions; the new head slowly emerges from the old skin which, with its empty eyes, is worked back beneath; the new feelers and legs are being drawn from their casings, and the future wings from their sheaths. At the end of six or seven minutes our locust—no longer pupa and not yet imago—looks as in Fig. 4, *b*, the four front pupa-legs being generally detached, and the insect hanging by the hooks of the hind feet, which were anchored while yet it had that command over them which it has now lost. The receding skin is transparent and loosened, especially from the extremities. In six or seven minutes more of arduous labor, of swelling and contracting, with an occasional brief respite, the antennæ and the four front legs are freed, and the fulled and crimped wings extricated. The soft front legs rapidly stiffen and, holding to its support as well as may be with these, the nascent locust employs whatever muscular force it is capable of to draw out the end of the abdomen and its long hind legs (Fig. 4, *c*). This in a few more minutes it finally does, and, with gait as unsteady as that of a new-dropped colt, it turns round and clambers up by the side of the shrunken cast-off skin and there rests, while the wings expand and every part of the body hardens and gains strength, the crooked limbs straightening and the wings unfolding and expanding like the petals of some pale flower. The front wings are at first rolled longitudinally to a point, and as they expand and unroll, the hind wings, which are tucked and gathered along the veins at first, curl over them. In ten or fifteen minutes from the time of extrication these wings are fully expanded and hang down like dampened rags (Fig. 4, *d*). From this point on, the broad hind wings begin to fold up like fans beneath the narrower front ones, and in another ten minutes they have assumed the normal attitude of rest. Meanwhile the pale colors which always belong to the insect while molting have been gradually giving way to the natural tints, and at this stage our new-fledged locust presents an aspect fresh and bright. (Fig. 4, *e*.) If now we examine the cast-off skin, we shall find every part entire, with the exception of the rupture which originally took place on the back, and it would puzzle one who had not witnessed the operation to divine how the now stiff hind shanks of the mature insect had been extricated from the bent skeleton left behind. They are in fact drawn over the bent knee-joint, so that during the process they have been bent double throughout their length. They were as supple at the time as an oil-soaked string, and for some time after extrication they show the effects of this severe bending by their curved appearence.

The molting, from the bursting of the pupa-skin to the full adjustment

of the wings and straightening of the legs of the perfect insect, occupies less than three quarters of an hour and sometimes but half an hour. It takes place most frequently during the warmer hours of the morning, and within an hour after the wings are once in position the parts have become sufficiently dry and stiffened to enable the insect to move about with ease, and in another hour, with appetite sharpened by long fast, it joins its voracious comrades and tries its new jaws. The molting period, especially the last, is a very critical one, and during the helplessness that belongs to it the unfortunate locust falls a prey to many enemies which otherwise would not molest it, and not unfrequently to the voracity of the more active individuals of its own species.—(Riley's Eighth Report.)

The egg (Plate LXII, Fig. 1, *c*) is curved, cylindrical, .21 inch (5½ millimeters) in length, more pointed at the posterior than the anterior end. The posterior end is contracted just before the extreme tip, which is smooth, the more or less regular pits which cover the chorion, or egg-shell, being here obsolete. I have been unable to discover any micropyle, or passage for the spermatozoa. The posterior end points downward in the egg-moss, so that the exit of the young locust from the anterior end is thus rendered easier. Although I have not seen the larva actually burst its way out of the egg, yet on the examination of between fifteen and twenty deserted egg-shells, I have, without an exception, noticed in them one, more usually two, slits extending from the head-end to the middle of the egg. The egg-shell is without doubt burst open by the puffing out or expansion of the membrane connecting the head and prothorax, just as the common house-fly or flesh-fly bursts off the end of its pupa-case by the puffing out of the front of the head. I have seen the embryo make its exit in two or three instances. In one case I saw a large piece of the egg-shell (chorion) fly off from in front of the face while the face of the embryo puffed slightly out, and in another instance the whole anterior end of the shell came off. In the locust I have observed, as will be seen farther on, that the amnion is ruptured by the forcible expansion of the membrane behind the head, the larvæ before walking lying on their backs or sides and forcing this membrane outward. This action probably begins before the shell is burst and seems amply sufficient to burst the brittle chorion, which is easily broken and peeled off by rubbing the egg between the fingers, leaving the serous membrane beneath. The pressure thus exerted must be a lateral one, and sufficient to rupture the chorion.

In his ninth report on the injurious insects of Missouri, Professor Riley maintains that besides "a continuation of undulating contractions and expansions of the body," the tips of the jaws and "sharp tips of the hind tibial spines," the shell is ruptured, and then "splits up to the eyes or beyond, by the swelling of the head." I think the swelling of the space between the head and thorax is sufficient to accomplish the rupture of the shell. It may be objected to Mr. Riley's account of the supposed action of the jaws and spines that, as may be seen by my Fig. 2, the position of the legs is such that the tibial spines do not point outward, the tibiæ being placed between the femora, and the legs are not displaced until after the amnion is shed. Moreover the spines are soft and flabby, as well as the legs; besides this the legs and the entire body are covered by the amnion, the tibiæ being smooth. Did the spines saw through both the chorion and serous membrane, the amnion would, of course, be ruptured. I also do not think that the jaws would be available until after the amnion has been cast. That the jaws are not moved out of their place until after the embryo leaves its egg-shell and throws off its

amnion, I was able to plainly see in a specimen, which the moment after the amnion was forced back from the head opened the jaws and thrust out the palpi and antennæ. The amnion is sometimes nearly shed before the embryo has entirely extricated itself from the egg-shell. The outer embryonal layer, or "serous membrane" of Kowalevsky, may be detected by rubbing off the chorion.

I have found six stages in the life-history of the Rocky Mountain locust, with consequently five molts, with the following characters as seen in the female sex of each stage:

1. First larval. Head very large, and abdomen short and small; antennæ 12-jointed. Length, 14–15^{mm}.

2. Second larval. Head smaller; antennæ 16-jointed; lower edges of tergum of meso-thoracic ring and especially meta-thoracic full and rounded. No difference from the first stage seen in a dorsal view; colors deeper, markings more distinct. Length, 7–8½^{mm}.

3. Third larval. Head about the same size proportionally as in the second stage; lower sides of meso- and meta-thoracic rings subacutely produced, evidently the rudiments of the wing-pods of the pupa. The proportion of the prothorax to the two posterior segments is the same as before. Length, 9–11^{mm}.

4. First pupal. Antennæ 20-jointed; prothorax much produced backward, wing-pods well developed, covering the tergum of the meso- and meta-thoracic segments, so far as they are not concealed by the overlapping of the prothorax; outer pair twice as large as the inner pair; the hinder pair 2½^{mm} in length, or two-thirds as long as the prothorax. Length, 15^{mm}.

5. Second pupal. Antennæ 22-jointed; prothorax still larger; hind wing-pods as long as the prothorax. Length 20^{mm} (1 inch).

6. Imago, or adult, with wings fully developed. Antennæ 23–24-jointed; eyes more rounded than in the pupa; hind femora slenderer. Length of body, 25^{mm}.

It will thus be seen that there are three larval and two pupal stages besides the adult stage.

The embryo locust.—On removing the living embryo from the egg-shell under (Plate LXII, Fig. 2), it is found that it lies with the legs folded on the side of the body, the fore and middle pair folded directly across the thorax, while the hind pair are laid along each side of the abdomen. The antennæ lie on the face each side of the clypeus and labrum, or upper lip. The eyes are dark reddish, and the head, limbs, and cross-lines on the back of the body are reddish mixed with yellow. Beneath, the body and legs are white. By putting the eggs in alcohol the shell becomes more transparent, so that the head, eyes, limbs, and reddish portions of the body become visible. Length of embryo at time of hatching 0.21 inch. Described from living specimens received from Mr S. D. Payne, Kasota, Lesueur County, Minnesota, March 1, 1877.* Either during the night of the 13th or early in the morning of the 14th of March nearly all the larvæ (the eggs having been kept in a warm room) hatched at the same time. The egg-shell bursts open at the head-end, when the larva immediately after extricating itself from the egg casts off a thin pellicle (the amnion or *faltenblatt*), as I have seen in the larvæ of the flea, currant saw-fly, and other insects. Before the skin is cast it is almost motionless, and by slight movements of the body in about five minutes draws itself out of the amnion. The pro-

* This shows that the embryo locust develops in the autumn immediately after the eggs are laid, and that it lies dormant (a few occasionally hatching in the autumn) during the winter, ready to burst its egg-shell in the spring.

cess of extrication is as follows: While it lies nearly motionless it puffs out the thin, loose skin connecting the back of the head with the front edge of the prothorax. The distension of this part probably ruptures the skin, which slips over the head, the body meanwhile curved over until the skin is drawn back from the head; when the latter is thrown back it withdraws its antennæ and legs, and the skin is in a second pushed back to near the end of the abdomen; finally it draws its hind tarsi out of the skin, and in a moment or two more the young locust frees itself and walks actively off, sometimes, however, with the cast skin adhering to the end of the abdomen.

Before the molting of the amnion the body and legs are soft and flabby; immediately after, it walks firmly on its legs. At 11 a. m. most all, one or more hundred, had hatched. They are pale-reddish, however, as in the embryo; by 3 p. m. they had begun to turn dark, and by 9 of the next day all were dark colored, as in the following description:

Description of the larva. (Plate LXII, Fig. 3).—The following description is taken from living young as they had just hatched in Salem, Mass., January 22, 1877 from eggs received from Mr. A. Whitman, of Saint Paul, Minn. The larva has a larger head and smaller abdomen than the pupa and has no rudiments of wings. They were blackish, marbled with flesh-color, with a dorsal white line behind the head. Legs flesh-colored, spotted irregularly with black. Hind thighs (femora) spotted with black, much as in the adult; toe-joints (tarsi) black. Head very large in proportion to the rest of the body; abdomen small, tapering rapidly toward the tip. Length, 0.17 inch. In another specimen (three living ones only examined) the back of the body had a reddish tint, as in older specimens observed living in Colorado.

Pupa (Plate LXII, Figs. 3, 4).—Ground-color, a deep reddish salmon-color on the head, body, and legs. Front of head below the antennæ black, marbled with white lines. Prothorax with a curved, broad, black longitudinal band on each side of the median line, and below a squarish black spot separated from the black band above by a conspicuous white stripe, and with two white spots on the lower edge. Rudimentary wings black, with fine pale lines and reddish flesh-colored along the costal edge. Hind legs blackish on the outside of the thighs (femora), interrupted by fine, salmon-colored lines. Abdomen whitish above and on the sides, spotted and marbled with black, forming broken lines; ventral side flesh-colored, not spotted. Hind shanks (tibiæ) black beneath, above flesh-colored, with the spines black. Length, 0.65 inch. Described from several living specimens taken at Manitou, Colo., July 16; hundreds of others seen in different parts of Colorado not apparently differing on casual examination.

In addition I may quote Mr. Riley's description based on living specimens observed in Missouri:

The pupa is characterized by its paler, more yellow color, bringing more strongly into relief the black on the upper part of the thorax and behind the eyes; by the spotted nature of the face, especially along the ridges; by the isolation of the black subdorsal mark on the two anterior lobes of prothorax, and by the large size of the wing-pads, which, visible from the first molt, and increasing with each subsequent molt, are now dark, with a distinct pale discal spot, and pale veins and borders. The hind shanks incline to bluish rather than red, as in the mature insect.

ADULT (Plate LXII, Figs. 1, 4, *e*, 5, 6).—After repeated examination of the variations of this species as compared with those of *C. femur-rubrum*, the only reliable characters I have been able to find are the following: The male and female *C. spretus* (normal Rocky Mountain form) differs from *C. femur-rubrum* in its much larger size, its proportionately longer and larger wings and usually lighter tints, and the larger, more distinct spots on the wings. I can see no difference in the ovipositor of the female. The most constant difference is in the form of the end of the male abdomen, which is narrow, elevated, and more or less deeply notched (see Plate I, Fig. 6), while in the male of *C. femur-rubrum* it is well-rounded, full, swollen, and the edge entire, with very rarely a slight tendency to a notch. The largest male from Colorado in my collection measured 1.30 inches. The small variety *Atlanis* I regard as a variety of this species, and not *femur-rubrum*, because it has the well-defined notch in the narrow, high abdominal tip. My Iowa specimens are darker than those from Colorado, Missouri, and Kansas, but a fine male from Arapahoe Peak, Colorado, is full as dark as those from Iowa.

The young do not leave the place of their birth until after the first month, but huddle together, not scattering, as most young insects do, they being gregarious at the outset. The small bands then unite into larger ones, and these mass into enormous armies. They are exceedingly ravenous, feeding upon each other when other food is exhausted. Riley says that "the young insects move, as a rule, during the warmer hours of the day only, feeding, if hungry, by the way, but generally marching in a given direction until toward evening. They travel in schools or armies, in no particular direction, but purely in search of food, the same school often pursuing a different course one day to that pursued the day previous." In Missouri, the young moved in a general northerly direction. They seldom move, when half-grown, "at a greater rate than three yards a minute, even when at their greatest speed, over a tolerably smooth and level road, and not halting to feed. They walk three-fourths of this distance and hop the rest." It is in the young wingless condition that the locust is most to be feared, and, on the other hand, most easily subdued.

THE ROCKY MOUNTAIN LOCUST NOT PERMANENTLY ABUNDANT AND INJURIOUS EAST OF THE PLAINS.

It has been abundantly proved by Professor Riley and others that the locust will not be destructive east of longitude 93° or 94°, namely, the western edge of the Mississippi Valley. We have seen that the progeny of the swarms from the plains lying on the flanks of the Rocky Mountains which at intervals infest the western border of the Mississippi basin generally return northwestward. The cause of their northwestward migration is in all probability due to the prevailing southerly and easterly winds of June and early July; but those that are left are said to be enfeebled and degenerated. Mr. Riley attributes this to the low altitude and moisture of the Mississippi Valley, the locust flourishing and most prolific in the dry elevated plateaus of the Rocky Mountains. Professor Riley thinks that the length of the summers of the western Mississippi States as compared with the short hot summers of the plains another cause of its inability to live permanently east of the plains in large numbers. To use Riley's own words:

Assuming that I have correctly placed the native home of the species in the higher, treeless, and uninhabitable plains of the Rocky Mountain region of the northwest, and that it is subalpine, we may perhaps find, in addition to the comparatively sudden change from an attenuated and dry to a more dense and humid atmosphere, another tangible barrier to its permanent multiplication in the more fertile country to the southeast in the lengthened summer season. As with annual plants, so with insects (like this locust), which produce but one generation annually, and whose active existence is bounded by the spring and autumn frosts, the duration of active life is proportioned to the length of the growing season. Hatching late and developing quickly in its native haunts, our Rocky Mountain locust, when born within our borders (and the same will apply in degree to all the country where it is not autochthonous), is in the condition of an annual northern plant sown in more southern climes; and just as this attains precocious maturity and deteriorates for want of autumn's ripening influences, so our locust must deteriorate under such circumstances. If those which acquired wings in Missouri early last June had staid with us long enough to lay eggs, even supposing them capable of doing so, these eggs would have inevitably hatched prematurely, and the progeny must in consequence have perished.

The fact that some changes are undergone by the eastern progeny of the Rocky Mountain locust is substantiated by two good observers, quoted by Mr. Riley, as follows:

Mr. Riley is of the opinion that the grasshoppers run out in a few generations after they leave their native sandy and gravelly soil. My experiments, so far as they go verify that opinion. For several years I have caught grasshoppers during early sum,

mer that came fresh from the direction of the mountains, and by attaching their legs by fine silk threads to a small spring balance, found that their physical strength was from 25 to 50 per cent. greater than that of grasshoppers treated the same way that were hatched in Nebraska or in States farther eastward or northward. The same result was reached by caging them, and ascertaining how long they would live without food, and also by vivisection. In some places, also, the eggs that were laid in different years since 1864 did not hatch out. The changes from extreme wet to dry, and from cold to hot weather, or some other unknown causes, seem to sap their constitutional vigor. Were it not for this, long ere now these grasshoppers would, from their enormous numbers, have desolated the whole country as far east as the Atlantic.—Prof. Samuel Aughey, of the University of Nebraska, in the Lincoln (Nebr.) Journal.

I have observed hundreds of winged locusts fall to the ground during flight, either already dead or soon dying. These, upon examination, have generally proved to contain no parasites, and I judge that their death was in consequence of impaired strength; this second generation, raised in an unnatural climate, not equaling in vitality the first generations, and succumbing to the fatigue consequent upon extended flight.—Prof. F. H. Snow, of Kansas State University, in Observer of Nature.

This view is also held by Mr. Whitman, of Minnesota.

Mr. Riley states that in Missouri "the specimens which hatched in and left our western counties last spring were, on an average, somewhat darker and smaller than their parents." It thus appears that the Rocky Mountain locust is affected like most other animals or plants when removed from their proper geographical limits; but a few insects, such as the Colorado potato-beetle, &c., being able to withstand a change of climate. As will be seen below, a variety of *spretus* head is found in Northern New England, Illinois, and the Pacific coast. Though born and bred outside of the dry and elevated Rocky Mountain plains, are dwarfed and prevented by moisture and various natural causes, such as the presence of forests, &c., from increasing in large numbers and migrating. These dwarfed individuals are a climatic variety of *C. spretus*, which has been named *atlanis* by Mr. Riley, who, however, believes that it is a truly distinct species from *C. spretus*. But from a careful study of the geographical variations of a number of moths common to the Atlantic and Pacific States as well as the Rocky Mountain region, I have found that Rocky Mountain and usually Pacific coast specimens are larger and with longer wings than eastern examples.

(See my monograph of *Phalænidæ*, Hayden's United States Geological Survey, p. 584, 589.)

It appears that the var. *atlanis* collected in Illinois was first examined by Mr. Uhler and named *C. spretus*, but as Mr. Thomas's specimens of *spretus* came from the locust-area of the plains, and his description applies to the genuine *spretus*, his name should be regarded as the authority rather than Mr. Uhler, whose name was not accompanied by a description, so far as I am aware.

"It is somewhat strange," says Prof. C. Thomas, in the zoology of Lieutenant Wheeler's Survey, p. 892, "that the first specimen ever examined and named should have been found in Southern Illinois by the writer and sent to Professor Uhler, of Baltimore, about the year 1860, though previous to that time various scientific expeditions had penetrated the western plains; yet it is but seldom seen in the section where that specimen was obtained." It is not impossible that the few specimens of *C. spretus* said to have been seen east of the Mississippi have flown over from the eastern limits of the locust-area in Minnesota, Iowa, or Nebraska, and that it is not a permanent resident, just as the Asiatic migratory locust occurs temporarily in England and Sweden. The variety called by Mr. Riley *C. atlanis* is, however, common in Illinois, and extends west to central Missouri. This is a smaller form, with shorter wings, and markings more like the eastern locust, but differing decidedly in the notched end of the hind body of the male. There is

great difference of opinion in regard to this form. Mr. Riley was the first to describe it fully, and I quote his description:

Caloptenus atlanis, n. sp.—Length to tip of abdomen, 0.70–0.85 inch; to tip of closed wings, 0.92–1.05 inches. At once distinguished from *femur-rubrum* by the notched character of the anal-abdominal joint in the male, and by the shorter, less tapering cerci; also by the greater relative length of wings, which extend, on an average, nearly one-third their length beyond the tip of the abdomen in the dried specimens; also by the larger and more distinct spots on the wings—in all which characters it much more closely resembles *spretus* than *femur-rubrum*. From *spretus*, again, it is at once distinguished by the smaller size, the more distinct separation of the dark mark running from the eyes on the prothorax and of the pale line from base of wings to hind thigh; also by the anal joint in the ♂ tapering more suddenly; and by the two lobes forming the notch being less marked. From both species it is distinguished not only by its smaller size, but by the deeper, more livid color of the dark parts, and the paler yellow of the light parts—the colors thus more strongly contrasting.

6 ♂'s, 7 ♀'s from New Hampshire. Just as the typical *femur-rubrum* is at once distinguished from the typical *spretus* by the characters indicated, so *atlanis*, though structurally nearer to *spretus*, is distinguished from it at a glance by its much smaller size and darker, more marbled coloring. The contrast is all the greater in the living specimens, and I have seen no specimens of *spretus* that at all approach it in these respects.

Whether this is the *femur-rubrum*, as defined by De Geer or by Harris, it is almost impossible to decide, though Harris's figure of *femur-rubrum* better represents it than the true *femur-rubrum* as subsequently defined by Thomas, and as found in Illinois and Missouri.

I have collected this grasshopper in Central Maine, and at Amherst, Mass., where it is not uncommon, and could be easily confounded with the eastern red-legged locust, (*C. femur-rebrum*). It is also common in Essex County, Massachusetts, and has been since 1864, as seen by specimens in the museum of the Peabody Academy of Science at Salem. Mr. S. H. Scudder has also specimens from New Hampshire, and it is not improbable that it is a widely-distributed form, with a range approximating to that given on the map. I am inclined to regard it as by no means a distinct species, but as an eastern variety of *C. spretus*, replacing that species on the Atlantic coast and in the Mississippi Valley. In this region it will probably never become injurious. Mr. Thomas regards it as a variety of *C. femur-rubrum* rather than *C. spretus*. In speaking of *Caloptenus femur-rubrum*, he remarks as follows:* "A few specimens taken in Iowa. These belong to the typical form, but they and all others obtained within the last two or three years appear to me to be slenderer and more like Riley's *atlanis* than in former years. That this species has been undergoing some modification in the Mississippi Valley within the last three or four years I think must be admitted. Although Riley's *atlanis* is certainly but a variety of *femur-rubrum*, yet it can be separated from the latter at a glance, and when the specimens are fresh without opening the wings or examining the posterior abdominal segments."

It should be borne in mind that the western *spretus* differs from the *femur-rubrum* in the much longer wings and its larger size. The legs are the same in both, while *spretus* is paler, with shades of dull yellow and red. The legs are of the same length in both, and the spines (ovipositor) in the end of the body are the same in the two species. These differences I find constant after careful examination of twelve specimens of each species, and of many others more superficially studied. The male of *spretus* differs decidedly from that of *femur-rubrum* in the characters already pointed out, namely, in the narrow, prominent, deeply-notched tip of the abdomen, as well as the short fork in the complete tergal piece of the abdomen. On the other hand the end of the body of the male of *femur-rubrum* is rounded, full, and entire, and not thickened, yet I have observed in one or two of the specimens of the male *femur-*

* Proceedings of the Davenport Academy of Natural Sciences, 1876, p. 260.

rubrum from Essex County, Massachusetts, a slight tendency of the abdomen to become notched, and I should not be surprised to find intermediate links connecting the variety *atlanis* with *femur-rubrum*, but with the evidence now before me, especially the occurrence in California of diminutive short-winged male *spretus*, scarcely distinguishable from the eastern *atlanis*, the two specimens agreeing well in the form of the abdominal tip. I am inclined to the belief that *atlanis* is simply a variety of *spretus*. Speculating on the origin of the two species, I should consider, that *femur-rubrum* being on the whole the more widespread species, that *spretus* originated from it after it (*femur-rubrum*) had attained its present distribution, and that *spretus* assumed its larger size and great length of wing on the hot and dry central plateau of the Rocky Mountains.

Practically considered the two injurious forms are the genuine *spretus* and the genuine *femur-rubrum*. It is the latter which is so abundant and destructive at times in the New England States and Canada. Having known the insect so well for twenty years in Maine and New Hampshire, I am surprised to find in Mr. Riley's seventh report the suggestion that the *femur-rubrum* "had been confounded" with his *atlanis*, and "had played the part of a migratory locust in the White Mountain region of Maine and New Hampshire." The form *atlanis* is a comparatively rare one in New England. During the summer of 1874, '75, and '76, in Massachusetts at least, it has been very rarely met with, compared with the ordinary red-legged locust, and must have been so in 1864, judging by the labels on the specimens in the museum of the Peabody Academy of Science, and I have little doubt but that it has always been a comparatively scarce insect, while the genuine *femur-rubrum* abounds in countless numbers each summer and autumn from Maine to Massachusetts, and I suppose all over its destructive limits as laid down on Map II.

I have received a male and female of *C. spretus*, var. *atlanis*, from Mr. Henry Gillman, of Detroit, who collected them "near Laughing Fish River, Michigan,* on the south shore of Lake Superior. This river falls into Traine Bay, an indentation of the coast to the eastward of Marquette. These specimens measured thus, from head to tip of wings when folded, male 1.08, female 1.10 inches; *atlanis* from Massachusetts, male 1.02, female 1.12 inches; *atlanis* from Illinois, male 0.92, female 0.95 inch; *atlanis* from California, male 0.99 inch. On the other hand a male *C. spretus*, normal form, from Iowa, measured 1.30, while an average male from Colorado was 1.34 inches in length. Ten specimens of Iowa *spretus*, the offspring of emigrants from the Rocky Mountains, were slightly smaller and considerably darker than specimens from Missouri, Kansas, and Colorado, approaching slightly but perceptibly var. *atlanis* and *femur-rubrum*. I have the idea that if the normal form of *spretus* were permanently acclimated in the Mississippi Valley, it would change to var. *atlanis*.

I should add that the conclusions regarding the varietal nature I have above stated are written out from notes made two years since after careful examinations, and in 1874, and again in 1875, while I have at the present time of writing re-examined the subject and come to the same conclusion as I held in 1874.

DOES THE ROCKY MOUNTAIN LOCUST INHABIT THE PACIFIC COAST?

Prof. C. Thomas remarks as follows in the Zoology of Lieutenant Wheeler's Survey, p. 892, 1876, concerning the westward distribution

* Riviere aux Poissons qui rit, of the French Voyageurs.

of this species: "So far as I can learn, it has not yet been found in California; but as it is found immediately east of the Sierra Nevada, it is quite probable that it reaches to the Pacific, though it may not be migratory on the west side of the range." Previous to this, in his Acridiдæ of North America, (Hayden's Survey, 1873, p. 165), he remarked, "I have traced this species from Texas northward to the north shore of Lake Winnipeg, in British America, and from the Mississippi River westward to the Sierra Nevada range. It does not appear to be found in California, and but a short distance southward in Arizona. I am half-way inclined to the opinion that future investigations will show that this is really the destructive species in California, and not *Œdipoda atrox*, for it would seem impossible for the latter to sustain itself during a lengthened flight with its short wings."

Mr. Scudder thus writes me regarding the occurrence of *C. spretus* in California: "On looking over my cabinet I find two or three specimens, probably received from Mr. Edwards, with printed label 'California and Nevada,' which I should be very unwilling to separate from *spretus*."

In the autumn of 1875 I received from Mr. Edwards two specimens, labeled *C. spretus*, from California; one was a male, the other a female. The male I compared with a living male *spretus*, var. *atlanis*, caught at Amherst, and found no differences in size or length of wing, except that the wings were more clearly spotted and the body lighter colored. I then considered it as *C. spretus*, and published a note to that effect in the American Naturalist for October, 1875, vol. ix, p. 573.

On sending the two specimens to Mr. Scudder for identification, he writes me that the female "is apparently *femur-rubrum* and the other probably *bilituralis* Walker, though it is pretty hard to be sure of Walker's species. I have both of these from Vancouver's Island (Crotch)."

On a fresh comparison of Mr. Edwards's male, which he and I refer to *spretus*, I found it to be of the same size and length of wing as Massachusetts *atlanis*, but on comparing it with *C. spretus* from Northern Missouri, it does not seem to me to differ, except in being considerably smaller and in having shorter wings; in coloration and style of markings, particularly the general pale-reddish and dull-yellowish tints, and especially the distinct spots on the wings, it is a true *spretus*. Some observers may call it variety *atlanis*. I should prefer to regard it as a small subvariety of *spretus*, and regard *atlanis* as confined to the Eastern States. However, as far as our present knowledge goes, I should conclude that *spretus* occurs west of the Sierra Nevada as well as east, but have not extended its range on the map beyond Utah and Idaho, except conjecturally. It is to be hoped that collectors in California will settle all doubts as to the range of this species in the Pacific States, and collect it in such numbers that satisfactory comparisons may be instituted between the Pacific coast form and the genuine *spretus* and the form *atlanis*. Meanwhile, Mr. Henry Edwards, so well known for his extensive entomological researches in Oregon, California, and Nevada, sends me the following notes under date of September 10, 1876: "Now as to *Caloptenus spretus*, I first found this species in large numbers about 20 miles north of San Francisco, in Marion County, in May, 1875. Previous to that time, though known to me by a few scattered individuals, it had never appeared in great abundance, but at the above date it was in immense quantities in the locality indicated, though it appeared to prefer the dried-up grass to the green and growing corn and other cereals which were close at hand. I have heard of no serious complaints whatever of the destructive qualities of this insect, and am inclined to

think that it is not yet much to be dreaded in California. We have no other species that I am aware of in large numbers. *Spretus* has been taken by me near Portland and at the Dalles, Oregon, and still more abundantly at Victoria, Vancouver's Island, but I have never seen it in the Sierras; my idea being that it is always (here at least) confined to the valleys and plains. In proof of this, the locality in Marin County to which I have alluded is at the base of Mount ———, and on the sides of the mountain itself the grasshoppers were not found at all. I do not think it goes far south of San Francisco. I have seen one or two from Santa Barbara, but none from below that point. Perhaps it may be replaced by another species. We have no literature that I know of on the subject, save a few newspaper notices, which I will try to find and send to you. At present, we are strangely exempt from all destructive insects."

California in former years has had its locust invasions, although we are entirely uncertain as to the species forming the swarms. In different parts of California they have appeared in the following years, according to Mr. A. S. Taylor (Smithsonian Report for 1858): 1722, 1746–1749, 1753 and 1754, 1765–1767. In the present century they have been abundant and destructive about 1827 or 1828, about 1834 or 1835, and in 1838, 1846, and especially in 1855.

THE GEOGRAPHICAL DISTRIBUTION OF THE ROCKY MOUNTAIN LOCUST.

A glance at the accompanying map, showing the distribution of the Rocky Mountain locust (*Caloptenus spretus*), will show the probable limits within which it will be found. At least there is no probability that the locust will ever afflict farmers east of the limits assigned.

The eastern limits have been defined by Professor Riley for Texas, Indian Territory, Missouri, Kansas, Nebraska, and Minnesota, while the northern and northeastern limits have been indicated by Prof. G. M. Dawson. The southestern limits are somewhat conjectural, but have been indicated to me by Maj. J. W. Powell. The western limits in Nevada and Idaho have been pointed out to me by Prof. Cyrus Thomas.

The range of the small variety (*atlanis?*) in California and British America (Vancouver Island) has been indicated by Messrs. H. Edwards, S. H. Scudder, and myself; while the eastern range of the eastern variety *atlanis* has been indicated by Messrs. Riley, Thomas, Scudder, and myself.

The locust area is divided into two regions, one the permanent breeding-places, on the elevated plains among the Rocky Mountains and the great plateau lying east and extending approximately to longitude 102°. Beyond the edge of the great plains are found the temporary breeding-places of the locust, which comprise the prairie-lands of the border States as far east as longitude 93° or 94°. The arrows with simple shafts indicate the course of the migrations from the original, usually permanent, breeding-places, and the arrows with a feathered shaft the return migrations from the temporary breeding-places periodically visited.

THE MIGRATIONS OF THE ROCKY MOUNTAIN LOCUST OF THE WEST.

In dealing with this fearfully-destructive insect, which has attracted so much notice from the public, and in seeking for remedies against its devastations, it is of prime importance to have a thorough knowledge of its breeding-places, the frequency and extent of its migrations, and to seek for the connection between the direction of the winds and other meteorological phenomena and the flights of the locust.

The locust is quite or nearly as destructive in Africa, Asia, and Southern Europe as in this country, but the laws of their migrations and their connection with meteorological phenomena have never been studied in those regions, and it remains for the United States, with its Weather Signal Bureau, to institute, in connection with the scientific surveys of the West, investigations regarding the nature of the evil and the best means to overcome it.

In endeavoring to trace the connection between the migrations of the locust and the course of the winds at different months, the writer has been led into some theoretical considerations which seem to be supported by the facts presented in the unpublished report, and which may be confirmed or disproved by future investigations.

History of the migrations of the locust.—The following table, compiled from the reports of A. S. Taylor, the late Mr. B. D. Walsh, Prof. C. V. Riley, Prof. C. Thomas, Mr. G. M. Dawson, and the observations of Mr. W. N. Byers, together with the reports in the Monthly Weather Review, will show the years when the locust was excessively abundant and destructive in the different Territories and States, and also serve to roughly indicate the frequency and extent of the migrations of the destructive locust of the West. The dates which are starred are years when the progeny of the locusts of the preceding year abounded, and when in most cases there were no fresh incursions from the westward. The species referred to under the head of California, Washington, and Oregon may be some other than *Caloptenus spretus*.

Manitoba.	Minnesota and Western Iowa.	Montana and Dakota.	Wyoming and Idaho.	Utah.	Colorado.	Nebraska, Kansas, and Western Missouri.	Indian Territory and Texas.	California.	Washington and Oregon.
1818	1818	.....	.....	.....	.....	.....	.....	1827 or 1828	.....
1819	1819	.....	.....	.....	.....	.....	.....	1834 or 1835	.....
.....	1820	.....	.....	.....	.....	1820 or 1821	.....	1838	.....
.....	.....	.....	1845	.....	.....	.....	1845	.....	.....
.....	.....	.....	.....	.....	.....	1846?	.....	1846	.....
.....	.....	.....	1852	1852	.....	.....	1849	.....	1852
.....	.....	1855?	1855?	1855	1855?	1855	1855	1855	1855
.....	1856	.....	.....	1856*	.....	.....	1856*	1856*	.....
1857	1857*	.....	.....	1857	.....	.....	.....	.....	.....
1864	1864	1864	.....	.....	1864	.....	.....	.....	.....
.....	1865*	.....	.....	.....	1865*	.....	.....	.....	.....
.....	.....	.....	.....	1866	.....	1866	1866	.....	.....
1867	1867	.....	.....	1867	1867	1867	1867	.....	.....
1868*	.....	.....	.....	1868*	1868	1868*	.....	.....	.....
1869	.....	.....	.....	1869	.....	1869*	.....	.....	.....
1872	.....	.....	.....	1870	.....	.....	.....	.....	.....
.....	1871	.....	.....	1871	.....	.....	.....	.....	.....
.....	slight.	.....	.....	1872	.....	.....	.....	.....	.....
.....	1873	1873	1873	.....	1873	.....	.....	1873	.....
1874	1874	1874	1874	.....	1874	1874	1874	Southern	.....
1875	1875	1875	1875*	.....	1875*	1875	1875	California.	.....
.....	1876	1876	1876	1876	1876	1876	1876	.....	.....

This table and the data on which it is based are necessarily very imperfect, owing to the vast extent of the territory over which the locust swarmed, and the fact that the greater portion is uninhabited, while the inhabited portions have been settled only within comparatively few years. It will be seen, however, that since 1873 the evil has been greater and more wide-spread than ever before.

The theory of the migrations.—(1) *The immediate cause of the migrations of the locust from its original breeding places is the unusual abundance of the species during certain years.* It has been found in some cases that

the exceptional years when the locust migrates are periods of unusual heat and dryness, conditions unusually favorable to the excessive increase of insect life. As may be seen in the accounts of the eastern locust, the grass army-worm, the grain-aphis, the chinch-bug, and other less destructive insects, when the early part of the season, the spring and early weeks of summer, are warm and dry, without sudden changes of temperature, insects abound and enormously exceed their ordinary numbers. When two such seasons occur, one after the other, the conditions become still more favorable for the undue development of insect life. Now it is well known that in the Eastern States the summers of 1860 and 1874, preceding the appearance of the army-worm and grain-aphis, were unusually warm and dry, and favorable not only for the hatching of the eggs laid the year previous, but for the growth and development of the larvæ or young. Look now at the conditions for the development of locust life on the hot and dry plains, chiefly of Dakota, Montana, Wyoming, and Idaho. We have no extended meteorological records from these regions at hand, but it is more than probable that the years preceding the migrations of the locusts were exceptionally warm and dry, when the soil was parched with long-sustained droughts, as we know that the corresponding species east of the Mississippi River abounds during dry summers following dry and warm springs.

Given, then, the exceptional years of drought and heat and the great extent of territory, and we have as the result vast numbers of young hatched out. The year previous having perhaps been warm and dry, the locusts would abound, and more eggs than usual would be laid. These would with remarkably few exceptions hatch, and the young soon consume the buffalo grass and other herbage, and move about from one region to another, following often a determinate course in search of food. In this way large broods may migrate a long distance, from perhaps twenty to fifty miles. In about six or seven weeks they acquire wings. Experience shows that the western locust as soon as it is fledged rises up high in the air, sometimes a thousand feet or much higher. They have been seen to settle at night on the ground, eat during this time, and toward noon of the next day fill the air again with their glistening wings. As more and more become fledged, the vast swarm exhausts the supply of food, and when the hosts are finally marshaled, new swarms joining perhaps the original one, the whole swarm, possibly hundreds of miles in extent, begins to fly off, borne by the prevailing westerly and northwesterly winds, in a generally easterly and southeasterly course.

(2.) *The secondary cause of the migration is the desire for food, and possibly the reproductive instinct.* The fact that in their migrations the locusts often seem to select cultivated tracts, rapidly cross the treeless, barren plains, and linger and die on the prairies and western edge of the fertile valleys of the Missouri and Mississippi, indicates that the impelling force is due primarily to the want of food, and that the guiding force is the direction of the prevailing winds, for they have no leaders, and we do not believe in the existence of a "migratory instinct" in the locust any more than in the grass army-worm, or the cotton army-worm, which it is sufficiently evident migrate from field to field, simply in search of more abundant food.* Meanwhile the reproductive system of

*The simple fact that the more extensive migrations of the locust both in the New and Old World are periodical, long intervals existing between them, suggests that the development of a migratory instinct would be impossible. If once partially implanted, the long succession of non-migratory years would effectually break up the germs of such an instinct. It may be quite different with birds, which perform their annual migrations for years and perhaps centuries without fail.

the locusts is maturing, the eggs ripening, and the uneasiness of the locusts during the course of their travels may be unconsciously stimulated by the sexual instincts and the desire to discover suitable places for egg-laying, a long and tedious operation.

It has been sufficiently shown that a swarm of locusts observed by Professor Robinson near the entrance to Boulder Cañon, Colorado, traveled a distance of about six hundred miles to Eastern Kansas and Missouri. Though the swarm was first observed at some distance north of Denver, Colo., it was then on its way from the north, and may have come from some part of Wyoming two or three hundred miles northwestward or northward. Though the winds may vary and counter-currents exist, and storm-gusts from due north, such as often sweep over the plains, and local southerly breezes may retard their flight, the course is either eastward or southeasterly. We know enough of the winds in the Western States and Territories to lay down the the law that the general direction of the winds in July and August, along the eastern slope of the Rocky Mountains and on the plains, is from the west and northwest, and accords with the eastward course of the locust swarms. The relations between the average direction of the winds and the migrations of the locust have, however, never been sufficiently studied, either, so far as we are aware, in Europe or in this country. And yet, if we would intelligently study the causes of the excessive increase and migrations of the locust, we must examine the meteorological features of the country, ascertain the periods of drought and undue rain-fall, the average direction of the wind for the different months, in order to learn how far they correspond with the phenomena of insect-life. That there are meteorological cycles, dry and hot seasons recurring at irregular intervals, while the general average may remain nearly the same century after century, is supported, though it may be vaguely, by observed meteorological facts.

The question then arises, *Can meteorologists predict the coming of seasons of undue heat and drought, and consequently can we predict insect-years? That is, the migrations of locusts and the undue increase of the chinch-bug and army and cotton worm?* I believe that we shall, after the lapse of years, be able to foretell with a good degree of certainty locust invasions, and be able to provide against the losses thus incurrred.

On the frontier of the Western States, in Colorado, or in the Territories of Wyoming, Montana, and Utah, where the losses from the ravages of the locust cannot easily be made up by importations from contiguous Territories, it seems the most practicable mode to provide in years of plenty against years of want. We should imitate on a grand scale the usage of the ancient Egyptians under Pharaoh, who laid up in times of unusual harvest stores of grain for times of famine. It is said that this has been done on a small scale by the Mormons. If this were done in the far West, in seasons immediately preceding insect-years, which had been predicted by entomologists in conjunction with the meteorologists, we should be saved the distress, destitution, and even loss of life from starvation, which have resulted from ignorance of the laws regulating the appearance of destructive insects, especially the western locust.

The return migration.—By simultaneous observations for a number of years over the region liable to be visited by migratory hordes of locusts, added to the knowledge we already possess, it will not only be possible to predict the course of certain swarms from their breeding-places, and their probable destination, so that when a swarm starts from Montana or Wyoming, its arrival in Colorado a week or a fortnight later may

with some certainty be predicted, and, again, its arrival in Kansas and adjoining States be announced with a certain amount of precision, as has already been done by Dr. Riley, but we shall be able to foretell the course taken in the return flight of their progeny in the succeeding year. I will confess that previous to my visit to Kansas and Colorado, in 1875, I was skeptical as to Dr. Riley's opinion that there was a general movement in a northwest course of the young of the previous year, broods from Missouri and adjoining regions northwestward. The facts and resulting theory have already been stated in full by Dr. Riley and others. It remains to determine the causes of this return migration, this completion of the "migration-cycle," as Professor Dawson terms it. It is evident that in this case the desire for food is not the cause, for food is many times more abundant in the Mississippi Valley than on the plains whither they return. The solution of the problem, I think, must be sought in the direction of the prevailing winds during the middle of June, the time when they become winged. It may be found, after a series of careful meteorological observations, that the prevailing winds at this early season are southerly and southeasterly. It has been shown by meteorologists, as I learn from Prof. C. Abbe, that during May and June the winds blow inward toward the heart of the continent from the Atlantic Ocean and Gulf of Mexico. On application to General A. J. Myer, Chief of the Signal-Service of the United States Army, for the meteorological data necessary to confirm this hypothesis, I promptly received a full summary of data observed by the officers of the Weather Signal Bureau, for periods of from two to five (usually the latter) years between 1871 and 1876, which show that the prevailing winds in June, in Davenport, Dodge City, and Keokuk, Iowa; Saint Paul and Breckenridge, Minn.; Yankton and Fort Sully, Dak.; Omaha, Leavenworth, and Fort Gibson, Ind. T.—all within the locust area—are from the southeast and south. This fact may be sufficient to account for the prevailing course of the return migrations of the locust from the eastern limits of the locust area.

The accompanying table is taken from a synopsis of the meteorological phenomena of the Western States and Territories within the eastern limits of the locust area, which is appended to this chapter. It has been furnished me by Brig. Gen. A. J. Myer, U. S. A., Chief Signal-Officer, Washington, D. C., and my hearty thanks are due him for the labor and trouble involved in its preparation.

Station.	May.					June.					July.					August.					September.					
	1872	1873	1874	1875	1876	1872	1873	1874	1875	1876	1872	1873	1874	1875	1876	1872	1873	1874	1875	1876	1871	1872	1873	1874	1875	1876
Davenport, Iowa	NW	NE	SW	E	SW	SW	SW	SW	NW	SW	NW	SW	SW	E	SW	SW	SW	E	S	SE	SSE	SW	SW	SW	SW	.....
Dodge City, Iowa	....	....	....	N	E	....	....	...	S	SE	...	....	....	NE	SE	....	....	....	S	S	....	....	....	....	S	.....
Keokuk, Iowa	W	E	S	SE	S	S	SE	SW	SE	NW	NW	SE	SW	SW	E	S	SW	E	S	S	NE	S	NW	S	S	(?)
Saint Paul, Minn	W	N	N	SE	SE	SE	SE	SE	SE	NW	S	SE	SE	NW	SE	S	SE	SE	SE	SE	SE	NW	SE	SE	.....	(?)
Yankton, Southern Dak	NE	S	NW	SE	...	S	SE	SE	NW	.....	S	SW	SE	S	.....	E	SE	SE	SE	.....	....	NW	NW	NW	...	.....
Omaha, Nebr	SSE	N	S	SE	S	SSE	S	S	S	N	SE	S	SW	SE	S	SSE	S	S	S	S	SE	SE	S	S	S	.....
Breckenridge, Minn	SE	SE	SE	SE	SE	SE	SE	SE	SE	NW	SE	SE	S	N	SE	SE	SE	SE	SE	SE	.....	SE	NW	S	NW	.....
Fort Sully, Central Dak	NW	E	SE	NW	SE	SE	SE	SE	SE	NW	SE	SE	SE	SE	SE	SE	ESE	SE	N	SE	.....	NW	NW	SE	N	(?)
Fort Gibson, Ind. Ter	E	SE	SE	SE	....	SE	SE	S	W	.....	SE	SE	S	E	.....	E	E	SE	SE	.....	.....	SE	SE	.....	.....	.....
Leavenworth Kans	SW	S	S	S	S	SW	S	S	S	S	SE	S	S	S	S	SE	S	S	S	S	E	SW	S	S	S	.....
North Platte, Nebr	....	....	....	SE	SE	....	....	....	SE	N	....	....	....	NE	SE	....	....	....	SE	SE	....	....	....	....	SE	(?)
Bismarck, Mont	....	....	....	S	SE	....	....	....	E	NW	....	....	....	NE	NW	...	....	....	NW	NW	....	....	....	....	NW	.....
Cheyenne, Wyo	N	W	W	W	W	W	W	W	W	W	W	W	S	S	S	W	W	W	NW	NW	NW	NW	W	NW	.....	.....
Denver, Colo	N	NE	S	S	N	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	.....	S	S	S	S	.....
Colorado Springs, Colo	....	....	N	S	SE	...	....	S	S	N	....	....	NW	SE	N	....	....	NW	N	....	....	....	....	SE	N	.....
Santa Fé, N. Mex	N	SW	E	SW	SW	SW	N	SW	SW	SW	NE	SE	E	SW	E	S	SW	SW	SW	SW	.....	SE	SW	E	SW	.....

Let us therefore grant this setting-in of southerly and easterly winds, which may last until the locusts are winged. When they rise on the wing into the air they are known to move in a general northwest direction. It is highly probable that they are borne along by these generally southeasterly winds, and pass over on to the plains. The cause is seen, then, to be entirely independent of subsistence; possibly the reproductive instinct causes them to become uneasy, restless, to assemble high in the air and seek the dry, hot, elevated plateau of the northwest. Should this be so, the cause of their migrations is probably purely mechanical. Abundant testimony is at hand to show that they are wholly at the mercy of the prevailing winds, and that as a rule the course of their migrations is quite dependent on the direction of the winds, while the course of the winds depends more or less on the season of the year. We may expect that future research over sufficient territory will show that the June migrations, from the eastern limits of the locust area, will be toward the northwest, and the July, August, and early September migrations, from the Rocky Mountain plateau, will be in a general easterly and southeasterly direction.

It is not only of great scientific interest, but of high practical importance, to collect all facts bearing on the return migrations, in order to know where the locusts go in their return migrations the second year, as we only know that they do fly a certain distance northwestward. We want to ascertain the extreme western limits of this return migration. We also want to learn whether they return to their original breeding-places on the eastern slopes of the Rocky Mountains, or whether the westerly winds, if they are westerly, drive them back and scatter them, so that they do not breed extensively.

It will be seen by the reader that all grounds for a reliable working theory of locust migrations are based on the work of our Signal Bureau and local observers, and that the observations of the meteorologists and entomologists must go hand in hand. The Government has provided a well-organized corps of meteorological observers, and we submit that a number of competent entomologists should take the field, under Government auspices. Not only should the border States, especially Texas, Kansas, Nebraska, Minnesota, and Iowa, employ competent entomologists, following the liberal policy of Missouri, which for eight years has had a State entomologist, whose reports have proved of incalculable practical value, as well as of great scientific interest, but the habits of the locust need first of all to be thoroughly studied in the Territories, particularly those of Wyoming, Montana, Idaho, Dakota, Utah, New Mexico, Arizona, and in the State of Colorado. A commission of entomologists should be appointed to make a thorough detailed study for several successive seasons of the habits of the locusts in the Territories mentioned. It would seem that the recommendations made at the recent meeting of western governors at Omaha, that an appropriation be made by Congress, and a commission be attached to the existing United States Geological and Geographical Survey of the Territories, is the most feasible and economical method of securing the speediest and best results.

Let us for a moment look at the losses sustained in the United States from the attacks of insects. The annual agricultural products of this country by the last census amounted in value to $2,500,000,000. Of this amount we in all probability *annually* lose over $200,000,000 from the attacks of injurious insects alone. Dr. Riley avers that the losses during 1874 in Missouri from locusts, and it will be remembered that only the western third was invaded, exceeded $15,000,000. This

would make the losses in other parts of the West at least twice as much more, or $45,000,000 in all. The estimated money-loss occasioned by the chinch-bug in Illinois in 1864 was over $73,000,000; in Missouri, in 1874, it is estimated by Dr. Riley to have been $19,000,000. The annual losses from the chinch-bug are greater, Mr. Riley says, than from any other insect. The average annual loss to the cotton crop from the attacks of the cotton army-worm alone is estimated at $50,000,000. Adding to these the losses sustained by the attacks of about a thousand other species of insects which affect our cereals, forage and field-crops, fruit-trees and shrubs, garden vegetables, shade and ornamental trees, as well as our hard and pine forests and stored fruits, and it will not be thought an exaggeration to put our annual losses at $200,000,000. If the people of this country would only look at this annual depletion, this absolute waste, which drags her backward in the race with the countries of the Old World, they might see the necessity of taking effective preventive measures in restraining the ravages of insects. With care and forethought, based on the observance of facts by scientific men, we believe that from $50,000,000 to $100,000,000, or from one-quarter to one-half of this annual waste, could be saved to the country. And the practical, most efficient way is for the States to cooperate with the General Government in the appointment of salaried entomologists, and of a United States commission of entomologists, who should combine the results of the State officials, and issue weekly, or, if necessary, daily bulletins, perhaps in combination with the Weather-Signal Bureau, as to the conditions of the insect world, forewarning farmers and gardeners from week to week as to what enemies should be guarded against and what preventive and remedial measures should be used.

The Weather-Signal Bureau, first suggested and urged by the late I. A. Lapham, was not instituted without ridicule and opposition, but it has saved millions to our commerce and agriculture. The maintenance of an entomological commission and the appointment of State entomologists would involve comparatively little expense. Already, owing to the full information regarding the invasion of Missouri by the locust in 1874, contained in the reports of Prof. C. V. Riley, the people of that State will be well prepared, from the direful experience of the past, to deal more intelligently and efficiently with the locust in the future.

THE MIGRATORY LOCUSTS OF CENTRAL AND SOUTH AMERICA.

We have already referred to the fact that swarms of locusts of unknown species have occurred at different dates in Guatemala and other parts of Central America. The following notices are taken from an article by A. S. Taylor, of Monterey, Cal., published in the Smithsonian Report for 1858: "Throughout California, with its ante-1849 boundaries, throughout Lower California, New Mexico, and all the dry and the elevated mesas or plateaus of the republic of Mexico, their ravages have been noted by the old Spanish chroniclers from the first conquest and settlement of the countries." In 1632 the parishes of Mexico and Pinola, and other parts of the uplands of Guatemala, were overrun with locusts. Clavigero witnessed locust invasions in 1738 or 1739 upon the coasts of Xicayan, in Oaxaca. Afterward a famine occurred in Yucatan.

Regarding the injuries of a Guatemalan locust, we quote the following account from Squier's Honduras; descriptive, historical, and statistical, 1870:

The insect, however, which is most dreaded in Honduras, as indeed in all Central America, is the *langosta* or *chapulin*, a species of grasshopper or locust, which at inter-

vals afflicts the entire country, passing from one end to the other in vast columns of many millions, literally darkening the air and destroying every green thing in their course. I once rode through one of these columns which was fully ten miles in width. Not only did the insects cover the ground, rising in clouds on each side of the mule-path as I advanced, but the open pine-forest was brown with their myriad bodies, as if the trees had been seared with fire, while the air was filled with them, as it is with falling flakes in a snow-storm. Their course is always from south to north. They make their first appearance as *saltones*, of diminutive size, red bodies, and wingless, when they swarm over the ground like ants. At this time vast numbers of them are killed by the natives, who dig long trenches two or three feet deep, and drive the *saltones* into them. Unable to leap out, the trench soon becomes half filled with the young insects, when the earth is shoveled back, and they are thus buried and destroyed. They are often driven in this way into the rivers and drowned. Various expedients are resorted to by the owners of plantations to prevent the passing columns from alighting. Sulphur is burned in the fields, guns are fired, drums beaten, and every mode of making a noise put in requisition for the purpose. In this mode detached plantations are often saved. But, when the columns once alight, no device can avail to rescue them from speedy desolation. In a single hour, the largest maize-fields are stripped of their leaves, and only the stems are left to indicate that they once existed.

It is said that the *chapulin* makes its appearance at the ends of periods of about fifty years, and that it then prevails for from five to seven years, when it entirely disappears. But its habits have never been studied with care, and I am unprepared to affirm anything in these respects. Its ordinary size is from two and a half to four inches in length, but it sometimes grows to the length of five inches.

Mr. Taylor remarks that "this statement is consonant with the accounts received from Honduras and Guatemala of the famine and pestilence of fever in those countries in 1855 and 1856, caused by clouds of locusts devastating the country, and confirms Gage's history of the same lands in 1632." In 1855 the valley of Colima, in Southwestern Mexico, was visited by locusts.

In 1856 their ravages extended along the first central mesas or steppes bordering eastward the Rocky Mountains, covering the dry soils of Texas, and down into the south of Mexico. In the vicinity of Cordova, in the State of Vera Cruz, the people made a regular campaign against them, and succeeded in destroying one hundred and ninety-two arrobas, computed as numbering four hundred million grasshoppers. In the State of Guerrero they also did great injury, particularly within the districts around Acapulco.

The treeless portions of South America are also not exempt from swarms of locusts, though we have no information as to the different species composing them. Taylor says that at the time of the visit of Darwin to Chile and the adjacent countries of South America he relates of the grasshoppers as follows, at the date of March 25, 1835, when he was crossing the dry country which lies between the city of Mendoza, in Buenos Ayres, and the opposite side of Chile. This country assimilates in every essential physical characteristic to that of the territories within the boundaries of Upper and Lower California prior to the American occupation:

"Shortly before arriving at the village and river of Luxan, we observed to the south a ragged cloud of a dark reddish-brown color. At first we thought it was caused by some great fire on the neighboring plains, but we soon found that it was a swarm of locusts. They were flying northward, and with the aid of a light breeze they overtook us at the rate of ten or fifteen miles an hour. The main body filled the air from a height of twenty feet to that, as it appeared, of two or three thousand feet above the ground. The sound of their wings was as the sound of chariots of many horses running to battle; or rather, as I should say, like a strong breeze passing through a ship's rigging. The sky, seen through the advanced guard, appeared like a mezzotinto engraving; but the main body was impervious to sight. They were not,

however, so thick together but that they could escape a stick waved backward and forward. When they alighted, they were *more numerous than the leaves in the field*, and the surface became reddish instead of green. The swarm having once alighted, the individuals flew from side to side in all directions. Locusts are not an uncommon pest in this country. Already during this season several smaller swarms had come up from the south, where, apparently, as in all other parts of the world, they are bred in the deserts. The poor cottagers in vain attempted, by lighting fires, by shouts, and by waving branches, to arrest the attack. This species of locust closely resembles, and perhaps is identical with, the *Gryllus migratorius* of Syria and Palestine."

THE LOCUSTS OF THE OLD WORLD.

That the calamities which have befallen the farmers of the West are less grievous than those resulting from locust invasions in the Old World; that there is a general similarity in the habits of locusts the world over, and that the causes of their migrations are of the same general nature, may be seen by a perusal of the following statements, which I have taken from sources as a rule inaccessible to most readers. For brief popular accounts of the Old World locusts the works of Kirby and Spence, Westwood, and of subsequent compilers may be consulted. The following historical sketch of locust invasions in the Old World is condensed from an article by Rudolf Gottschaff in "Unserezeit," (February, 1876, Leipzig). The first account after that of Joel, in the Bible, whose remarks apply to Egypt, Syria, Palestine, and Asia Minor, is the statement of Ororius, that in the year of the world 3800 certain regions of North Africa were visited by monstrous swarms; the wind blew them into the sea, and the bodies washed ashore "stank more than the corpses of a hundred thousand men." Another locust plague, resulting in a famine and contagious disorders, according to St. Augustine, occurred in the kingdom of Masinissa, and caused the death of about 800,000 men. Pliny states that the locusts visited Italy, flying from Africa. In Europe locust invasions have been recorded since 1333, when they appeared in Germany. Mouffit states that in 1478 the country about Venice was invaded, and 30,000 people died of famine. In 1725 the region about Rome was overrun by locusts.

In France, swarms appeared at the close of the middle ages. In 1747 there was a great invasion of Southern and Middle Europe, especially the shores of the Danube, Wallachia, Moldavia, and Transylvania. Before and after this date vast swarms were observed in Africa and Asia. Adansin in 1750 observed them in the Senegal. In 1799, Jackson, in his "Journey through Morocco," states that the whole country between Mogador and Tanger, on the borders of the Sahara, was covered with them, and they were in many cases borne into the ocean westward.

In Russia, whose southern steppes form the home of the locust, vast swarms in the time of Charles XII, who was then in Bessarabia, came there from the region of the Black Sea. Russia, Poland, and Hungary were often visited by them. In 1828 and 1829 enormous swarms invaded the coast of the Black Sea. In 1859, in the South Russian provinces of Cherson, and in Bessarabia, a tract 60 versts long and about one-third as wide was overrun by them. Taschenberg gives the locust years in Russia in the present century as follows: 1800, 1801, 1803, 1812–'16, 1820–'22, 1824 and 1825, 1828–'31, 1834–'36, 1844, 1847, 1850, and 1851, 1859 and 1861.

In August, 1384, according to Mr. J. Boll, they invaded portions of Switzerland.

In Germany the records go back to 1333. In this year, and until 1336, they abounded. Entering Hungary, they overflowed into Poland and Austria. They then divided into two great swarms, one of which flew southerly into Italy, the other into France, Suabia, Bavaria, Thuringia, and Saxony. In Germany they again occurred in 1543. In 1693 they invaded Thuringia, going from Hungary by way of Austria, Schlesia, and Bohemia, and invading the region about Jena, Gotha, Erfurt, and Weimar.

In Germany the locust years were as follows: 1333–'36, 1475, 1527 and 1543, 1636, 1686, 1693 and 1696, 1712, 1714, 1715, 1719, 1727–'31, 1734, 1746–'50, 1752–'54, 1759, 1761, and for the present century, 1803, 1825–'30, 1856, 1859. In 1873–'74 small numbers appeared in swarms about Genshagen, near Berlin; they laid their eggs, and in the middle of June of 1875 the larvæ appeared in millions, becoming fledged in July.

Köppen has published (Horæ Soc. Ent. Ross. iii, pp. 89–246) an elaborate memoir on the migratory locust of Southern Russia. He gives, in the first place, a biography of his subject, which includes several memoirs published in Russian journals. With regard to the species Köppen remarks on the various opinions of entomologists as to the relation between *Pachytylus migratorius* (Linn.) and *P. cinerascens* (Tab.), and comes to the conclusion that the two supposed species are to be regarded as varieties of one and the same, and that *Edipoda tatraica* (Motsch.) is identical with *P. cinerascens*. The form which he met with most abundantly in South Russia is the true *P. migratorius*.

The development of the insect is described by Köppen in detail. The eggs are deposited by the females, to the number of 60 to 100 together, in little nests surrounded by a membranous envelope. The eggs are laid in autumn and the young hatched in the following spring. The envelope is burst a little while before the exclusion of the young. The eggs display a great power of resistance to the influence of cold; they have been found to retain their vitality when the temperature reached 26° Fahrenheit when placed with earth in a large glass vessel.

The larvæ are said by Köppen to moult four times, and the fourth moult produces the winged insect. The different stages are described by Köppen. At the end of May (1861), eggs taken from the ground showed the eyes, antennæ, segments, and legs of the larvæ distinctly; and a little while before hatching, the larvæ could move within the egg. On its emergence the larva is yellowish-white, with a rosy tinge; in three to four hours its color is grayish-black. Before and during each moult the larvæ are sluggish. At the final moult, which always takes place in the hottest sunshine, the animals hang head downward, by the hind feet, upon the stalks of grasses, &c. This enables the insects to twist about in all directions, in order to free themselves from the skin. The expansion of the wings occupies about twenty minutes after the completion of the moult (twenty-two minutes according to Köste, who says that the moult itself occupies sixteen minutes); during this period Köppen observed that a dark yellow fluid was distributed over the wings in microscopic drops. The period which elapsed between the arrival of the insect at the winged state and the deposition of the eggs is uncertain; the statements of different authors vary between four weeks and two months.

Köppen describes the nearly indiscriminate voracity of these insects, but remarks that certain plants appear to be avoided by them, namely, flax and hemp, the *Cucurbitaceæ*, and, according to Petzholdt, dwarf

garden-beans. The *Gramineæ* seem to furnish their favorite food. They prefer the leaves and other soft parts of plants and trees, but also sometimes gnaw the bark and even the wood of the latter. In time of scarcity they will attack straw-thatch and woolen clothes, and even devour each other. Köppen notices the statement made by various authors that the larvæ for the first ten days live upon dew, and treats it as an absurdity.

The perfect insects copulate almost immedialely after the last change of skin. The union of the sexes continues apparently for a considerable time, from twelve to eighteen or even twenty-four hours, but sometimes only for an hour or two. The female carries the male about with her, and feeds as if alone; she is, however, unable to fly. The male sits quite motionless, only giving a sign of life by stridulation if another male should approach.

The eggs are deposited about seven days after copulation,according to Köste. The female digs a hole in the earth of about 1½ inches, by means of the hook-like horny organs of the apex of the abdomen, and the eggs are then laid in cylindrical masses, usually placed at an angle of about 45° to the surface. The eggs are united by a spongy mass (cement), which also envelopes the whole outside of the mass; here, by the adhesion of grains of sand, small stones, &c., it forms a sort of wall which protects the eggs from injurious external influences. The mass is sometimes formed wholly or partially of the frothy cement without eggs. Yersin ascribes this to a morbid condition of the female, and doubts whether the few eggs contained in such masses are capable of development. Köppen has found, on removing the female insect, that the pit which it had dug was filled with the frothy mass without any eggs. This seems to the recorder to indicate rather that the cement mass is first produced by the insect, and the eggs afterward laid in it. The nests found containing the spongy mass without eggs would then be easily accounted for, on the supposition that the females were disturbed or destroyed when just about commencing the actual business of oviposition. The number of eggs laid in each nest seems to vary from 50 to 90 or 100, and the ovary of the female contains from 100 to 150 eggs, according to Krünitz. The question whether the females copulate more than once has been much discussed in Russia, and from the author's statements it would appear that the popular opinion is that the act of copulation only takes place once. From Köste's observations, however, it is certain that the females copulate and deposit their eggs several times. He observed a female in confinement which copulated with six different males before laying her first batch of eggs; and afterward the same phenomena were repeated four times, the insect dying when engaged in oviposition for the sixth time. From his own observations, and those of other authors, Köppen regards it as most probable that copulation and oviposition are repeated usually at least three times by each female, perhaps at intervals of about a month, as stated by Yersin, the total number of eggs being from 160 to 170.*

Upon the rapidity of movement of locusts in the larval condition the

*In an article by V. Graber "on polygamy and other sexual relationships in the *Orthoptera*" (Verhandlungen der zool.-botanischer Gesellsch. in Wien, xxi, pp. 1091–1096, Zoological Record for 1871), the author details experiments regarding polygamy and repeated copulations in some orthopterous insects. A male and female were observed *in coitu* eight distinct times between May 21 and June 1; after the sixth connection the female began to deposit eggs. A second male, which had already fecundated several females, was then placed with her, and she paired at least five times with him. Analogous results followed experiments upon *Pezotettix pedestris*, and he believes that polygamy and polyandry exist in many species.

statements of authors are at variance. The observations of Sydon and Dönzingk give about a quarter of a German mile (*i. e.*, about 0.975 mile English) in the hour. Téchemewsky asserts that they only advance about 350 feet in the day upon grass land.

Of the senses of the locust, Köppen seems to regard hearing as the sharpest. The senses of smell and taste are exerted in the selection of food; and that of touch is displayed in the sensibility of the insects to changes of weather, especially temperature. Sociability is regarded by the author as characteristic of the locusts. The larvæ proceeding from one nest seem to keep together for a time; they afterward associate in larger masses which move together in search of nourishment. These migrations in mass commence in the second stage of larval life, but become more general after the second moult. The migration usually takes place in the morning and evening. The author remarks upon the direction of the migrations of these insects, which he regards as influenced to a certain extent by an instinctive perception of the direction in which abundant food or a suitable breeding-place is to be found, but modified or even sometimes caused by external agents, especially the winds. The author also discusses the primary causes of the great migrations of these insects and the phenomena observed during their flight.

In the south of Russia the hatching of the eggs takes place, according to the weather, at the end of April or beginning of May. A few larvæ are sometimes produced on warm days in October, but these soon die. The hatching occupies from two to three weeks, according to circumstances. The winged insects appear in the beginning and middle of July; copulation takes place early in August; and the oviposition extends from the middle of August to October. The dry steppes constitute the chief haunt of the locusts; damp places they seem to avoid. The females prefer for the reception of their ova the solid virgin soil, and rarely visit ploughed land for this purpose. Damp and cold are unfavorable for the development of the eggs. The author discusses in great detail the external conditions which act favorably or unfavorably upon these insects. The greater part of this section is devoted to the consideration of their enemies, of which Köppen gives a formidable list (pp. 151–166).

Leimé and other authors have given Tartary as the true home of the migrating locusts; but in Tartary no large swarms occur. In the author's opinion, the countries in which the swarms are seen are also the countries of their birth. He cites many facts in support of this opinion, and in illustration of the geographical distribution of the insect, the northern limit of their migratory or nomadic life being a line passing from Spain through the south of France, Switzerland, Pomerania, South Russia, and South Siberia, to the north of China. To the north of this line the insects generally occur only singly. Many interesting details as to their occurrence in vast numbers are given by the author (pp. 190–205).

Köppen also describes the injury done by the locusts when they occur in great numbers, and indicates the means adopted for their suppression (pp. 205–246).

Köppen also notices *Caloptenus italicus*, a congener of our *C. spretus*, which likewise occurs in South Russia, and at such times, as in other regions of Southern Europe, sometimes in injurious numbers. Other species which are also occasional devastators, especially when associated with the migratory species, are *Pachytylus stridulus*, *Œdipoda vastator*, *Stauronotus vastator*, *S. cruciatus*, and *Pezotettix alpina*.

Küntsler reports this insect as injurious to corn-crops in Austria in 1866 and 1867.

The ravages of the locust in Bavaria have been discussed by Jaeckel,* who cites various records of the visits of this species in swarms during the fourteenth century, one toward the close of the fifteenth, and one at the end of the seventeenth century, and gives a long account of a similar visitation in 1749. Since that year no swarms of locusts have occurred in Bavaria.

Gerstaecker in a recent work† on the European locust, which seems to be mainly, however, a compilation, writes as follows regarding the European locust:

That copulation can be accomplished very soon after emerging from the last larva-skin (he does not name a *cupa stage*), is shown by the fact that one occasionally finds individuals engaged in the act while the wings are still tender and have not attained their full color. But the act is as a rule performed in the course of several days (after becoming winged), or even after a still longer period.

The male lets the female free in the course of twelve to twenty minutes, after which the female, before proceeding to lay, employs herself in feeding again for several days. As soon as her eggs are ripe, which, according to Kösten, requires seven days on the average, she seeks a satisfactory spot to deposit them. (He then describes the act of laying much like Professor Riley.) The eggs are generally found at a depth of 4 centimetres, or more, below the surface. In this act, requiring considerable time, she by no means rids herself of her whole stock of eggs at once, but may pass several weeks even in perfecting them. Possibly for a second or third deposit of the egg-mass a renewal of copulation is necessary. At least such a repetition has been noticed in the case of females that had already been found laying, and has always been followed by a new deposit of eggs. In all cases, whether after a single or repeated coupling, which latter may depend upon the relative number of males, and the temperature of the season, a division is made of the egg-stock into several deposits as is shown by the fact that the larger egg-pods seldom contain more than one-half, and the smaller very generally a much smaller fraction of the whole mass of eggs produced by one female, which mass may amount to one hundred and fifty or more. With the last deposit the female has accomplished her destiny, so that she not seldom remains dead on the spot where the laying occurred. On the other hand the males even after repeated coupling, and with several females, appear to be able to prolong their life, and may be found alive as late as October.

From the comparatively long time during which the winged locusts may be found, extending very commonly from the end of July to the end of September, it must not be at once concluded that the life of an individual is correspondingly long.

In selecting a spot for the perfection of this egg (packet) dryness is of the first importance to the female, and besides this a certain degree of hardness. They prefer loamy and clayey ground to pure sand. Besides this, a spot is naturally selected which offers suitable and plentiful food to the hatching brood.

Fallow fields lying alongside cultivated fields and meadows appear to present an unusual attraction to the female when ready to lay. That the eggs, as such, winter over under the surface can be set down as a matter of common observation. The young brood generally do not hatch before the end of April.

The geographical distribution of the migratory locust of Europe and Asia (*Pachytylus migratorius*) has been discussed by Herr F. T. Köppen in Petermann's "Mittheilungen aus Justus Perthe's Geographischer Anstalt," (1871, p. 361,) his paper being accompanied by a map showing the range of the insect. I translate an abstract of it by M. Preudhomme

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*Correspondenz-Blatt der Zool. Mineralogisch Verein, Regensburg. xxi, pp. 83–93. See Zoological Record for 1867, Verhaudlungen Zool. Bot. Gesellschaft, in Wien, xvii, pp. 930–932, Zool. Record for 1867.

†"Die Wanderheuschrecke. (Oedipoda Migratoria Lin.) Gemeinverstaendliche Darstellung ihren Naturgeschichte, Lebensweise, Schädlichkeit, und der Mittel zu ihrer Vertilgung. Im Auftrage des Königl. Preuss. Ministeriums für die landwirthschaftlichen Angelegenheiten verfasst von Dr. A. Gerstaecker, Prof. an der Universität in Berlin. Mit 9 Abbildungen auf 2 Tafeln in Farbendruck, Berlin, 1876. 67 pp."

For the above translation I am indebted to Mr. Whitman, who has kindly called my attention to the work.

de Borre, in the Comptr. Rendus of the Entomological Society of Belgium, 1871–'72, p. xviii:

The migratory locust is an *Orthopter* peculiar to the torrid zone and a large part of the north temperate zone of the Old World; but, in this last region, its northern limits is subject to some variations, the explanation of which is one of the principal objects of the work of M. Köppen.

In countries such as those of Arabia and Persia, where the mean temperature of the year, as that of the different seasons, is almost invariable, the abundance of the species in question does not vary; it is normally limited, both by the quantity of its nourishment and the natural enemies of the insect. But this is not the case in those countries which, like Southern Russia, may present, sometimes favorable seasons, sometimes years, or even simply seasons, unfavorable to the multiplication of *Pachytylus*. Thus, according to M. Köppen, the persistent prolongation of dry heat during a part of the autumn will exert an influence on the quantity of eggs laid in favorable places; and, on the other hand, a temperature less than 14° Réaumer, [63½° Fahr.,] prolonged for several days toward the end of May, will be indispensable to the hatching of the larva. There would result from the more or less perfect realization of these conditions, and their succession or their interruption during several years, those differences observed in the northern limit of the species, which alternately increase or diminish the area of distribution.

M. Köppen has distinguished and traced quite completely on the map for Europe and Siberia three different limits of the geographical area of *Pachytylus migratorius:* 1. The limits of its permanent distribution. 2. The limit of its temporary existence in all stages of development, a little more to the north. Finally, 3. The limits of its presence in the condition of bands of winged insects of a stated age, out of the regions where the species may live and propagate. It will be necessary still to establish the limits of accidental individual appearances, but that would be of questionable importance. The northern limit of the permanent geographical distribution of *Pachytylus migratorius* begins in Western Europe, from the coast of Portugal, near 40° latitude north, and extends from there toward the northeast as far as the mouth of the Bidassoa, thus leaving out all the northwest portion of Spain; it continues to rise obliquely in France up as far north as the lake of Geneva, and extends east, following more or less the forty-eighth degree of latitude, and embracing Valois, all of the north of Italy, Carinthia, and Hungary, it passes into Southern Russia, where it attains nearly the fiftieth degree, passes likewise across the middle of Siberia, whence it passes over the north of China, to end in Japan, at a latitude a little inferior to that of its point of departure in Portugal, leaving out the island of Niphon. M. Köppen remarks that all this limit does not deviate much from the isotherma of 16° R. [68° Fahr.] for the month of June. To farther circumscribe the area, so extensive, of this species, the line goes from Japan to the islands of Fidochi, to New Zealand and Australia, of which it only embraces the northern parts, passes from there to the island of Mauritius, then rises to the north, crosses Africa up to Madeira. But in this last part of the passage the limits are more hypothetical, from want of an exact knowledge of the existence of the species in the interior of Africa.

When, in a country comprised in this area, as has been frequently observed in Southern Russia, the locusts develop in a certain abundance, the want of food obliges them to migrate in part in different directions, and to break over their limits. If circumstances permit these emigrants to multiply for a certain period beyond their normal area, there results a temporary extension of this area, and occasionally new migrations to the north, until only a single spring, colder or more humid, comes to put an end to their invasion and to oblige them to go back to their natural limits. Temporary extensions like this of the area of distribution of *Pachytylus migratorius* took place in 1746 to 1749, and in 1822 to 1828; at these periods they appeared in Germany, and have multiplied themselves during several successive years. The northern limit of these temporary extensions may be also marked on the chart by a line which, taking its point of departure in the southwestern portion of Bavaria (where the *Pachytylus migratorius* has been observed from 1333 to 1339, and from 1748 to 1749), rises to the northeast by Jena and Halle toward Jüterbogk and Berlin, when it takes a nearly eastern course, following more or less the parallel of 52½° of latitude, near Müncheberg, Küstrin, Birnbaum, and Posen (regions which the species was known to have visited in 1730, 1752, and from 1827 to 1828); then the line passes across Southern Poland, at the fifty-second parallel, through the southern part of the government of the Mohilew, inclining gradually toward the south, and extending so as to reach the Wolga and the Ural. It is apparently to the humidity of the climate, injurious to the locust, likewise to the state of the eggs during the winter, that we should attribute the less extension of this limit toward the north in Western Europe.

To the north of the limits which have just been indicated, the *Pachytylus migratorius* has not the power of undergoing its whole cycle of metamorphoses, neither, consequently, to reproduce itself. This does not prevent its occasional appearance in swarms

even in countries very northern; thus, it was observed in England (1693 and 1748), and even at the latter date, near Edinburgh; in Sweden (as far as Ostrogoth), at latitude 57° to 58° north, in 1748 and 1844, and finally on the Duna, near Dunabourg and at Polozk, in 1545. But these troops of voyagers did not hatch out in the same places where they were observed, nor did they leave any progeny in subsequent years. The only known example of an exception to this rule is the discovery made once by Boheman, in September, in the middle of Sweden, of a *Pachytylus migratorius* in the proper state. Evidently this is an exception wholly accidental, which does not prove anything against the rule. The more we advance toward the north, the less are large swarms of locusts observed, and we end by meeting only isolated individuals, as have been seen several times at St. Petersburg, and even near Wasa in Finland (latitude 63° north).

The want of facts prevents our extending these studies to the southern boundary of the area of distribution of *Pachytylus migratorius*. However, we can remark that in New Zealand, the extreme southern point of this distribution, the mean temperature of the warmer months is, according to Schmid (Lehrbuch der Meteorologie, p. 363), at 15°.5 R. (about 66° Fahrenheit), which does not differ much from the corresponding temperature of the northern limit of the area in Europe.

The localities out of Europe where the *Pachytylus migratorius* has been observed are as follows: Madeira, Algeria, Tunis, Egypt, Chartoum, Asia Minor, Syria, Arabia, Persia, India, Siam, China, Japan, Java, Luçon, Fidschi, New Caledonia, New Zealand, Northern Australia, and finally Mauritius island; but this last locality indicated by Serville needs confirmation. In Central Asia the species has been observed near Lake Aral, on the borders of Syr-Darja, on the upper side of Ischim and of Irtisch, and finally toward the lakes Kurgaldschin, Nor-Saisan, and Balchaasch.

According to M. Köppen, the great chains of mountains are a powerful obstacle to the diffusion of *Pachytylus migratorius*. The Alps especially play a large part in its distribution in Europe, and it is without doubt to them that we should attribute its relative rarity in the countries of the southwest of Europe and northwest of Africa, where it is almost completely replaced by other species of the same group, *i. e.*, the *Caloptenus italica* in Spain, Italy, and in the middle of France; the *Acrydium peregrinum* in Algeria.

It should be observed that this species, and in general all the *Acrydiidæ*, shun mountainous and wooded countries. They are most fond of the plains, of regions quite dry, and it is also a circumstance which influences necessarily their geographical distribution.

"The development of the organs of flight of the migratory locust," continues M. Köppen, "determines the facility and the amplitude of its flight, and consequently favors its migrations. They are evidently the cause of this colossal geographical distribution of the species. They remind us of the remark of Darwin, that species rich in individuals and with a wide habitat, which, owing to their organization, have had in their country the pre-eminence over many surrounding species, are those which, in the case of emigrations out of their area, should have the greater chances of overrunning new territories."

Köppen examines successively the causes which may determine the migrations of this orthopter in armies more or less numerous, and then the observed direction of these movements. It is said that they fly more often from east to west, but M. Köppen thinks that it is not necessary to attribute this circumstance, as has been done, to the predominance of the east winds at times when the sterility of the country that they inhabit, increased still by the prevalence of these same winds, forces them to seek places which can furnish them a more abundant pasturage. Numerous facts appear, he says, to contradict this explanation. In reality, the movements of these hordes is rather centrifugal, as M. Köppen establishes from observations made especially in the plains of Eastern Europe; that is to say, that all the migrations appear to radiate from countries where the species breeds most. In Europe they would consequently be directed to the west, while in China they should have a direction ordinarily toward the southeast.

M. Köppen thinks that the same centrifugal radiation has presided over the scattering of this species beyond its original limits, and that this radiation, propagating in waves, such as we still see produced at the limits of its geographical area, has carried the species from its center of creation or its original country to points where it is powerless to overcome the climatic conditions or that concurrence of vital forces which are opposed to it. The center of creation or the point of departure of the species will be found, then, in Central Asia. The complete absence of this species on the American continent shows that it only began to exist as a species after the epoch of the separation of America from the Old World.

M. Prudhomme de Borre adds, "In this study, so interesting, there is one point on which we should insist. It is this, that the observations of M. Köppen tend to confirm the principle of zoological geography, that the area of a species cannot be limited on the map by a simple curve, but between places where the species exist in a constant or normal manner and those where its absence is constant there is always a zone, often

very broad, of temporary visitations, which is to the area properly so called what the penumbra is to the light, within the zone, of which the exterior limit is much more easy to trace than the inner; this last is subject to continual oscillations, with some undulatory movements, dependent on the centrifugal or expansive tendency of the species, and from the resistance which opposes it, and external circumstances, and evidently also the tendency of other species to spread out, with which it carries on a struggle for existence in endeavoring to maintain itself on an earth where the chances are divided, and even vary from year to year. M. Köppen has thus been enabled to figure on his chart three lines, as I may for the present call them, and the intermediate line represents the exterior actual limit of these oscillations of the true frontier line of *Pachytylus migratorius;* their amplitude may vary from two to four degrees."

The last thesis of M. Köppen that I shall draw attention to at this time, namely, that the absence of *Pachytylus migratorius* in America should prove that the species exists only as a species, since the separation of the two continents toward the north pole, seems to me scarcely necessary. A mere glance at the map which represents the area of distribution of this locust allows us to affirm without hesitation that that view is impossible. It is evidently not one of those species which we may call *circumboreal anteglacial*, because their presence in two forms (races, varieties, or species) on each continent indicates that they have had a common origin, a single area at that epoch, anterior to the glacial period, when the two continents were reunited in the Arctic zone by a bridge, so to speak, that is, a continuity of land, in conditions of climate which should allow the existence at that latitude of a fauna which only at present exists much farther south. The source of those species dispersed by the glacial period does not now probably exist in its integrity; but the two races confined, one in America, the other in the Old World, having undergone slow modifications each on its part, are to-day very analogous species, but as distinct by their external characters as by their separate geographical area.

Nothing like this applies to *Pachytylus migratorius;* it is one of those species which may be called *equatorial postglacial;* its expansion toward the north has been posterior to the glacial period, which would then have opposed it; and it can have no affinities in the New World, but degrees of consanguinity much farther removed than those unite the circumboreal species of the temperate zone. Thus, if, as some think, the northern hemisphere tends actually to retrograde toward a new period of cold, the *Pachytylus migratorius* is destined to see its area also retrograde toward the equator, and perhaps some day the western and eastern parts of this area may be completely disjointed, and, following this separation, its posterity may be so modified by isolation as to form two distinct species, as has occurred to circumpolar species.

In the discussion which followed, M. de Selys Longchamps speaks of the difficulty of separating *Pachytylus migratorius* (Linn.) and *cinerascens* (Fabr.), which he had at first regarded as varieties, but now considers as a distinct species, the latter being more sedentary and reproducing in Belgium year after year: "M. F. H. Köppen not speaking of *cinerascens*, it would be interesting to know whether he admits this species, and if in the affirmative, whether all his remarks apply alone to the true *migratorius* type, notably that which he says normally sojourns at Bayonne, where I have taken only *cinerascens*, variety *virescens*, whose characters are the same as in Belgium and Frankfort-on-the-Main. It is also *cinerascens* that M. von Heyden has taken."

Some notes on the Algerian locusts (*Acrydium peregrinum*, *migratorium*, &c.) by Coure, have been communicated to the Entomological Society of France by Giraud. In them, mention is made of a special work on the same subject, which the recorder has not yet seen. (Bull. Soc. Ent. Fr., 1867, pp. x, xiii.) The locusts visiting Algeria come from the south, and arrive in May. They lay their eggs soon after their arrival, and the young animals produced from these eggs usually become adult in July. In August all usually disappear. Coure also notices the arrival in Algeria in the early part of January, 1867, of a flight of locusts. The color of these was stated to be reddish. It appears that on first attaining their adult form, these insects are of a rosy tint, and afterward change; and Coure thinks that it is not until after their change of color that they are fitted for reproduction. Lallemant states (*l. c.*, p. xiii) that the locusts, which live for a long time in the adult

state, are at first rosy, then emigrate southward, and return in winter of their mature color.

In Spain, during the summers of 1875 and 1876, *Decticus albifrons* (Fabr.) was abundant and injurious, but less so in 1876 than the year previous, as the soldiers assisted the inhabitants of the district infested in destroying them.

In China records exist of the appearance of locusts in devastating numbers one hundred and seventy-three times during a period of nineteen hundred and twenty-four years, as stated by Andreozzi,* who has translated, from a Chinese work on agriculture, notes respecting the ravages of locusts in China, and the superstitions existing among the Chinese with regard to their origin. The three great causes of famine in China are placed as flood, drought, and locusts.

In Southern Australia locusts of an unknown species committed ravages in 1872. (See Proceedings of the Entomological Society of London, 1872, pp. xii–xvii).

EXTERNAL ENEMIES AND PARASITES OF THE ROCKY MOUNTAIN LOCUST.

When any insect abounds to an unusual extent, it has been found that not only its peculiar parasites abound in a corresponding ratio, but parasitic insects which prey usually on various other insects leave their ordinary hosts and attack the new-comers. Among the most important agencies which diminish the numbers of locusts, especially in the Mississippi and Missouri Valleys, are the insect-parasites. The birds destroy many, but the natural insect-enemies still more. The blackbirds, quail, prairie-chickens, and grouse were said to destroy many of the eggs in Minnesota. As samples of the accounts given by different writers, I give the following by Uriah Bruner, contributed to the "Inter-Ocean:"

Quails, paririe-chickens, and grouse, if sufficiently numerous, alone are sufficient to pick up every embryo grasshopper long before he can have wings. This I know from actual observation.

Seven years ago large areas of eggs were deposited on my farm near Omaha. I then was fortunate enough to have about fifty quails on my place. As soon as the hoppers were hatched, and while yet almost microscopic in size, I venture to say that each one of the quails picked up, every day, enough of them to fill a bushel-measure if grown to full size. They devoured all my grasshoppers long before their wings had developed; but the grasshoppers devoured no one's crops that year, and very few escaped to migrate. It seems, however, that that spring the young grasshoppers were destroyed everywhere where their eggs were deposited among us, and most persons will tell you that the cold spring rains killed them off. This is possible, where the rains were heavy enough to carry them off and drown them. But at that time quails, prairie-chickens, and grouse were plenty everywhere, and I suspect that rain-storms got credit for what the birds did.

Within the last six years we have had sporting-clubs in all our cities, towns, and villages, and very few birds survive the skill of the sportsman. Should any be fortunate enough to escape the sportsman, farmers' boys will trap and snare what are left during the winter and send them off to market. Was it not last winter that the report came back from Chicago, Saint Louis, New York, and other large cities that the market was glutted with quails, prairie-chickens, and grouse?

If my position is correct, is there any wonder that the grasshoppers that hatched in Missouri, Kansas, and Minnesota last spring have done so much damage before and after their migration? The wonder is that they did not more damage. If God in his mercy had not sent deluging rains throughout Missouri and Kansas, that swept most of them down the waters of the Missouri, and if in Minnesota herculean efforts had not been put forth to destroy them in their pupa state, the great Northwest might not to-day rejoice in the great harvest that is now ready to take in.

There can be no excuse for us to be eaten out by the grasshoppers, when hatched out among the settled parts of our country; and if we don't destroy them in their

* An extract from this translation is given by Stefanelli in the Bulletino Entomologia Società Italiano, 1870, pp. 70–82.—(Zoöl. Record for 1870).

embryo state we must lay the blame to ourselves if our farms are ravaged by them. Those hatched beyond the borders of civilization are not likely to visit us often nor do us much injury. We must protect quails and prairie-chickens. All of the Northwestern States must have statutory provisions against killing them for ten years, at least, and railroad companies must refuse, and by law must be prohibited, from carrying them over their roads for the same period. We must act and put in operation the knowledge we possess, or permit ourselves to be overcome by our insect enemies. It is for us to choose.

In "The Chicago Field" for March 17, 1877, Dr. Elliott Coues, United States Army, is inclined to place the sharp-tailed grouse (*Pediœcetes columbianus*) "if not at the head, at least in the very front rank of all the natural grasshopper-staying agencies. *These birds yearly destroy millions of grasshoppers*, and *at certain seasons eat very little else.*" As his article is a brief one and much to the point I insert it nearly entire:

I observe, in a late issue of the Chicago Field, that the question of the grasshopper-preying disposition of the prairie-hen is re-opened, though it is only through ignorance that any doubt on the subject can arise. Some three or four years ago I prepared and caused to be somewhat extensively circulated in the Northwestern States a brief reply to a question I found asked in one of the papers, "What will destroy grasshoppers?" stating in brief, "Prairie-hens will," and giving some facts bearing on the case. I never meant that these birds were a complete cure for the plague, but I endeavored to show what incalculable numbers of the pests the chickens destroyed, and to set their grasshopper-eating habits in the proper strong light. Probably few persons, outside the ranks of practical ornithologists are aware how extensively the so-called granivorous or seed-eating birds, such as sparrows, buntings, and finches, feed upon insects at certain seasons; and the same is true of the graminivorous birds, like grouse and partridges of all kinds. As for the peculiar insects now in question, namely, the grasshoppers, they furnish food to an immense array of quadrupeds and birds which inhabit the western prairies. The wolves, foxes, badgers, skunks, and various species of spermophiles or "gophers," all eat them. Among birds, the cranes, ducks, hawks, owls, grouse, and a great variety of small sparrow-like birds eat them. To just what extent these furred and feathered natural enemies make an impression upon the devastating hosts, cannot, of course, be known, for they have always been at work; but we may logically infer, from known facts, that the destruction is incessant, decided, and important to the last degree. Since, also, we do not know how delicately the contending forces of nature may sometimes be balanced in the perpetual "struggle for existence," it would be unsafe to assert that the diminution of the numbers of prairie-grouse by the incessant persecution to which pleasure or profit subjects them, is one of the principal causes of the late perilous swarming of the grasshoppers, but that there does exist to some degree a causative connection between the two circumstances, there can be, I think, no doubt.

With the prairie-chicken proper, or pinnated grouse, *Cupidonia cupido* of the books, I have had very little experience. There is, however, in its general habits, tastes, and proclivities, nothing materially different from what is the case with the sharp-tailed grouse, *Pediœcetes columbianus*, and this is a bird which I have had ample opportunities of studying for several years. I am inclined to place it, if not at the head, at least in the very front rank of all the natural grasshopper-staying agencies. *These birds yearly destroy millions of grasshoppers*, and *at certain seasons eat very little else.* Such a seemingly extravagant statement is supported, nevertheless, by actual observation and personal experience. I lived in Dakota in 1874, during the grasshopper invasion of that year, and was among the sharp-tails continuously from June until October, killing a great many of them "out of season" for scientific purposes, and in season for sport and food. In the latter part of summer, and in September, I invariably found grasshoppers in the crops of those I examined; and almost invariably I found the craws crammed with the insects, almost to the exclusion of other articles of diet. As I took occasion to say in the "Birds of the Northwest," 'At this season their food appears to be chiefly grasshoppers. I have opened numbers to find their crops crammed with these insects, only varied with a few flowers, weed-tops, succulent leaves, and an occasional beetle or spider.'

I don't pretend to say that the business of staying the ravages of the grasshoppers may be safely and confidently left to the grouse, or to any other natural agency—the hoppers have waxed too many for that; but I do assert, without fear of reasonable contradiction, that these birds are the natural means by which, in certain sections of the country, the greatest numbers of the insects are destroyed.

Among the many experiments which might be made with the hope of staying the ravages of this plague, the absolute, unqualified, and long-continued protection of the grouse might be tried. The denial of the sportmen's pleasures, and the stoppage of

one particular source of food-supply, which such course would entail, would go for nothing in comparison with the advantages that might result. I do not make the suggestion hastily, nor without due consideration, backed by personal observation, and fortified by logical induction.

We are always slow to acquire exact and full information respecting the food of the animals which surround us, notwithstanding that many or most of our quadrupeds, birds, and insects hold toward us relations of the utmost economic importance, and in spite of the unquestionable fact that all agricultural interests hinge upon the solution of the problems involved. A few years ago the cock-of-the-plains (*Centrocercus urophasianus*) was supposed to feed chiefly, if not exclusively, upon wormwood. I have killed them to find nothing but insects in their crops. Hawks, particularly of the genus *Buteo*, presumed to feed mainly upon small quadrupeds and birds, are immense consumers of grasshoppers in the West, at certain seasons.

One thing is certain, that if we are to use birds in our war against the invading hosts, we must employ our own, and no imported ones. The expensive, uncertain, and difficult experiment of introducing any alleged "acridophagous" species of the Old World will never, I suppose, amount to much. Moreover, it is not to the technically considered "insectivorous" birds that we may turn our attention hopefully. Though many of these small species feed habitually upon grasshoppers in season, their collective efficiency in the work of destruction appeared to be, and I have no doubt is, comparatively insignificant. At present I know of no birds capable of rendering more efficient service than the grouse.

Young locusts have been found by Professor Green, of Lawrence, Kans., in the stomachs of various birds, such as the red-eyed woodpecker, yellow-billed cuckoo, cat-bird, red-eyed vireo, great crested fly-catcher, and crow-blackbird. The hair-worm (*Gordius*) is a common parasite of the locust as of other species of grasshoppers. Mr. Riley states that many predaceous beetles attacked them, but few, if any, ichneumon-flies have been found in them, these beneficial insects confining their attention chiefly to caterpillars, such as the northern army-worm, &c. But the mite and Tachina flies are universally prevalent, and all writers agree are useful in reducing the number of locusts in the eastern border of the locust district.

June 2, before reaching Kansas City, I found on stepping off from the cars at different stations that the weak, feeble locusts were infested by large red mites attached to the base of the abdomen and to the under side of the wings.

The little red mite, which has proved to be such a benefactor to the people of the West, does not apparently differ from those found on the red-legged locust of the Eastern States in size or form. It is the six-legged young of some four-legged garden-mite, and has not yet been reared to adult life, and may be called *Trombidium gryllaria*.*

The scarlet silky mite.—Another mite, which is possibly the parent of the minute red six-legged parasitic mite, is the scarlet silky mite (*Trombidium sericeum* Say, Plate II, Fig. 4). It is about 2 lines in length, and has been abundant for two years in Minnesota, eating the eggs of the locust. As proof of its beneficial nature, I insert the following extract from a western paper:

Governor Miller, in a letter from Windom, says:

"Last evening, when we reached Worthington from Lake Shetek, there was quite an excitement in Worthington, owing to the fact that the citizens were generally convinced that a red parasite was destroying the grasshopper-eggs. I examined the matter carefully myself, and became convinced that the destruction of the eggs in that immediate vicinity was well assured; but I determined not to write you and excite any hopes until a further and more complete examination could be had. We therefore furnished our Bohemian friends with a bottle of the eggs, and their pests, and the commission left in high spirits. We postponed further investigation until this morning, when I left and prosecuted the examination with vigor. The farmers in the vicinity knew nothing of these signs of deliverance until the visitors from Worthington

**Astoma locustarum* of Walsh (no descr.); *Astoma gryllaria* of Le Baur; *Astoma gryllaria* of Riley.

reached them, and I feel safe in saying to you that in a circle of ten miles from Worthington there will scarcely be an egg left by to-morrow night. I send you a bottle herewith containing the cones and the parasites. We could scarcely find a cone, or sack, except as they were indicated by the parasite on the surface; and each cone which was not entirely destroyed had from five to fifty of the red laborers at work upon the eggs. We found scores of cells with no eggs left except the shells. As fast as the bug finishes one cone, it starts upon an expedition for new worlds to conquer, and it instinctively finds and conquers the new world. I, of course, informed our station-agents and others at Hersey and Heron Lake of this discovery, and they also promised to make a thorough investigation, as I will do here, and the results will be reported forthwith. If the matter is general, deliverance is nigh. * * * I stopped for fifteen minutes one and a half miles west of Wilder, where Section-Foreman Smith took me to that portion of his farm where eggs were deposited. We could find none by general digging; but wherever we found, as we frequently did, the red parasite on the surface, we found the cone beneath, with the parasite at work consuming the eggs. * * * I am aware that two years ago this parasite was found working upon the eggs at Madeira and other places, but here we have the remedy almost as soon as the eggs are laid, while in the former instances the parasite was only discovered in the spring."

It is bright red and oblong oval, as seen in the engraving. The *Tachina* fly (*Tachina anonyma* Riley) attacks the locust, depositing one or more eggs in the back, at the insertion of the wings. The young of the fly is a large white maggot. (See Plate LXIII, Fig. 3*a*, for the maggot of a similar fly.)

Description of the Tachina maggot.—The following description is based on three specimens received from Mr. A. Whitman, of Saint Paul, Minn., and said by him to have been taken from the body of a grasshopper (*C. spretus*). The body is flattened, cylindrical, tapering suddenly toward each end, the head-end being more pointed than the opposite extremity. The segments are quite distinct, with raised ridges. The head is minute, one-third as wide as the segment behind, with two black hooks, *i. e.*, the mandibles. The larvæ of the genus lack the little slender tubercles forming the rudimentary antennæ and mouth parts seen in *Anthomyia* and *Murca*. Length, .35 inch. The egg is said by Riley to be "oval, white, and opaque, and quite tough."

It is this fly probably which attacks the locust in the Western Territories, and I may add to the accounts of its habits given by Professor Riley (Seventh Report, p. 178), the following statement in a letter from Lieutenant Carpenter, dated Camp Robinson, Nebraska, December 27, 1876:

I have often observed a fly, about the size of the blow-fly, of a greenish mottled color with the abdomen tipped with red, annoying *Caloptenus spretus*. It would light on the ground just behind the grasshopper, and the instant it took wing would pounce upon it, and the two roll over and over on the ground struggling for several moments, when the fly would release the grasshopper. I have caught them both in this act, and upon examination of the grasshopper, always found the little red eggs on the body.

This fly is said by Riley to be common and destructive to the grasshoppers. Mr. Whitman writes me regarding its occurrence in Minnesota as follows: "I have opened six hundred and twenty-four grasshoppers (*spretus*); nine of these contained grubs (of the *Tachina* fly probably) and ten had hair-worms."

The locust-egg-eating maggot.—Another fly which is very useful from its habit of devouring the eggs of the locust is the *Anthomyia radicum* var. *calopteni* of Riley. It is quite similar to the onion-maggot and radish-fly, both in its maggot and winged states. I have received several of the maggots from Mr. Whitman said to have been found among the eggs of the locust. I give the following description of them:

Larva of Anthomyia radicum calopteni (Plate LXIII, Fig. 2).—Body long and slender, cylindrical, soft, elongate-conical, tapering gradually toward the minute head; the segments are not very convex; beneath they are thickened to take the place of feet. The antennæ and maxillæ form slender pointed tubercles much as in *Musca domestica*. The prothoracic spiracles are situated on the hinder edge of the segment, and are remarkably long and slender. The end of the body is full and rounded, flattened conical; the

end is divided into two portions, of which the upper forms a slope, on the lower edge of which are situated six acute tubercles, of which the three lower are the larger. In the center of the slope are two small, prominent spiracles, or breathing-holes. Below this slope is a transverse ridge, from which arise three sharp tubercles situated above the large anal tubercle or foot. Length about a third (0.30) of an inch.

I adopt Professor Riley's identification of this maggot.

Our figure is not drawn from specimens taken in this country, but copied from Curtis's Farm Insects. It is sufficiently accurate, however, to represent our form.

Professor Riley says that this maggot "is quite common, and has been found in Minnesota, Iowa, Nebraska, various parts of Kansas, Missouri, and even Texas. It has destroyed, in many instances, as many as 10 per cent. of them." These small maggots are found in the locust-egg pods, either singly or in varying numbers, there sometimes being a dozen packed together in the same pod. They exhaust the juices of the eggs and leave nothing but the dry and discolored shells, and when they are not numerous enough to destroy all the eggs in the pod, their work, in breaking open a few, often causes all the others to rot.

"When fed to repletion, this maggot contracts to a little cylindrical yellowish-brown pupa [-case], about half the length of the outstretched and full-grown larva, and rounded at both ends. From this pupa [-case] in the course of a week in warm weather, and longer as the weather is colder, there issues a small grayish, two-winged fly, about one-fifth of an inch long, the wings expanding about one-third of an inch, and in general appearance resembling a diminutive house-fly.

The common flesh-fly (*Sarcophaga carnaria*, Plate LXIV, Figs. 1–3).—The maggot (Plate LXIV, Fig. 1) of this fly also feeds on the eggs, but probably on those which are addled. It is larger than the *Anthomyia* maggot, with no spines around the end of the body; and the pupa-case (Plate LXIV, Fig. 2, enlarged) is much larger, truncate at the end, and tapering toward the head-end. I have received two specimens, half-grown, of the maggots of this species, taken from the abdomen of a locust (*C. spretus*) on the Vermejo River, New Mexico, June 29, by Lieut. W. L. Carpenter, U. S. A.

The two-lined Telephorus grub.—I have also received from Mr. Whitman, of Saint Paul, Minn., a specimen of the larva of *Telephorus bilineatus*, said by him to be destructive to the locust. I add a description copied from my first report as State entomologist of Massachusetts.

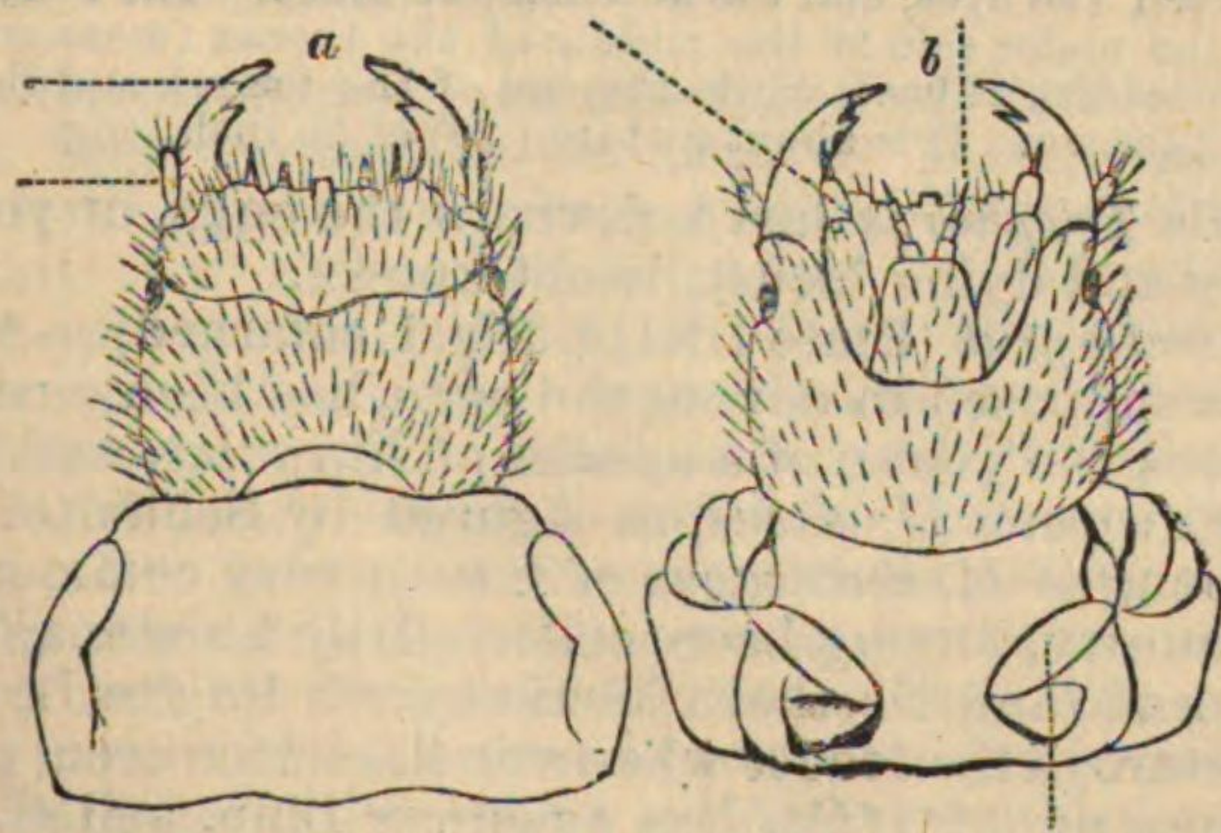

FIG. 2.—*Head of larva of two-lined Telephorus, enlarged.*

a, top view of head and prothoracic segment; *at*, antennæ; *md*, mandibles; *b*, under side showing *mp* the maxillary palpi; *lp*, labial palpi; *f*, first pair of feet.

The beetles of this and other species which belong to the family of fire-flies feed on the leaves of forest deciduous trees, especially the birch.

The larvæ, however, devour snails and insects, and do no injury to vegetation. The larva of this species was identified by Mr. P. S. Sprague, who found it near Boston, under stones in spring, where it changes to a pupa, and early in May becomes a beetle, when it eats the newly-expanded leaves of the birch.

Description.—The body of the larva is rather long and slender, thickest in the middle, where it is about twice as wide as the head, and tapers slightly toward each end of the body, the terminal segment being a little less than half as thick as the middle segment. The segments of the body behind the head are unusually convex, the sutures between them being very deep. The body is covered with fine, dense hairs, giving it a peculiar velvety appearance. Its general color is horn-brown, the head being darker. The head is remarkably flattened and square, being scarcely longer than broad, and densely covered with short hairs above and beneath. The antennæ are inserted on the side of the head, and immediately behind them on the side are the eyes; the occipital suture is situated midway between the base and the front edge of the head, forming a straight line just behind the eyes. The antennæ are two-jointed, and received into a large socket; the first joint is very short; the second joint four times as long as the first, a little slenderer, and increasing slightly in width toward the end, which is abrupt, and contains a minute, rudimentary third joint. The maxillæ are broad, subtriangular, projecting a third of their length beyond the labium, with the ends broad and square. The palpi extend out from the head as far as the antennæ, and are three-jointed, with the basal joint quite thick, rather longer than thick, while the second joint is very short, and one-half as long as thick; the third minute, rudimentary. The anterior edge of the occiput beneath is deeply hollowed out; the chin (mentum)is oblong, with very square edges, and is one-fourth longer than broad. The labial palpi are two-jointed, the basal joint very short, one-half as long as broad; second nearly twice as long as thick, and ending in a stiff hair. The mandibles are large, stout, two-toothed, the inner tooth situated a considerable distance from the tip. The labrum is broad and perfectly square in front, with a median notch dividing the edge into two slight lobes. The clypeus is an ill-defined oval, convex area.

Along the median line of the body is a slightly-marked row of short, paler streaks, more continuous on the thoracic than the abdominal segments, forming on each of the latter segments an elongated spot situated on the anterior edge of each segment except the last. On each thoracic and the last abdominal segment is a pair of lateral oval brown spots, paler in the center. Behind these on each abdominal segment (except the last) is a row of pale short lines, placed in the middle of the segment. Farther down on each side is a similar row of short lines, which are, however, subdivided into two spots, which on the thoracic segments form a row of four or five pale dots. Between these two lines is a row of black dots, one on each segment. The legs are rather short, and quite hairy. The terminal segment of the abdomen is about as long as broad, and well rounded behind. It is three-quarters (.75) of an inch in length. The pupa was not preserved. The beetle itself is soft-bodied, brownish-black and reddish-yellow. Its specific name (*bilineatus*) was given to it from the two short, broad, blackish bands on the prothorax, which is reddish-yellow. The head is reddish-yellow, with a broad black band between the eyes, and the antennæ are black. The body beneath is pale reddish, except the under side of the middle of the thorax (meso and meta thorax). The legs are pale reddish at base, while the end of the femora and the tibiæ and tarsi are entirely black-brown. It is about a third (.30) of an inch long.

Whether this *Telephorus* larva devours the eggs, or young larvæ, or only the sickly and dying locust, is not known.

The ground-beetle grub (Plate LXIII, Fig. 1, enlarged).—Another beetle-grub, which is supposed to devour the eggs, has been received from Mr. Whitman. It is the young of a species of *Harpalus*, and is allied to the larva of the European *H. æneus*, as figured by Schiödte, and may possibly be the young of *H. herbivagus* of Say, a very common beetle found all over the country, having been collected by Lieutenant Carpenter in Southern Colorado and Northern Mexico, according to Le Conte, so that it probably destroys the locust wherever the latter occurs.

The *hair-worm parasite* (*Gordius aquaticus* Linn. and *G. varius* Leidy, Plate LXIII, Fig. 6, see explanation of the plate).—I have received from Mr. Whitman fragments of a hair-worm found by him in the Rocky Mountain locust, but, unfortunately, comprising neither end of the animal, so that it is impossible to tell which species it is. It is probable that it belongs to *Gordius aquaticus*, as I have received one of that species from

Mr. Riley, taken from *C. spretus* in Missouri. Regarding the frequency of its occurrence in *C. spretus*, Mr. Whitman writes, under date of September 19, 1876: "I have opened six hundred and twenty-four hoppers (*spretus*); nine of these contained grubs (of the *Tachina* fly probably) and ten had hair-worms. I do not know that the latter has ever been noticed in hoppers in this State before this year; at any rate, it has been so rarely mentioned that I never heard of it here. I ought to say in regard to the six hundred and twenty-four grasshoppers above mentioned that they were probably some of a band of outsiders that have come into the State within a few weeks. Almost every female had eggs about ready to be laid." The specimen of *Gordius* received from Mr. Whitman was filled with eggs.

I will here give a *résumé* of our entire knowledge of the hair-worm, both because the worm is well known to the public, being sometimes thought by the ignorant to be actually a transformed horse-hair, and because it is prevalent in the bodies of grasshoppers, and has an extremely interesting history.

The first notice of the hair-worm in this country by a naturalist is, so far as I am aware, contained in "The Natural History of Vermont," by Zadock Thompson. The following account is quoted at second-hand from Charles Girard's "Historical Sketch of *Gordiaceæ*:" *

> The little animal called the *hair-snake* also belongs to this order (*Annulata*), and to the genus *Gordius*. These are very common in the still waters and mud in all parts of the State. They are usually about the size of a large horse-hair, and are from 1 to 6 or 8 inches in length. In color, they vary from pure white to nearly black, and hence we probably have several species. The vulgar notion that they originate from hairs which fall from horses and cattle and become animated in the water would seem to be too absurd for contradiction, and yet, absurd as it is, people are to be found who believe it.

Mr. Girard adds:

> The same popular opinion is prevailing in Europe. *Gordii* have been noticed in the body of insects; also, by an American entomologist, Dr. Th. William Harris, who says, "I have taken three or four of these animals out of the body of a single locust." They have been found by others within the cricket (*Acheta abbreviata*).
>
> We saw a specimen 6 or 7 inches in length caught in the clear waters of the vicinity of Richmond, Va. Several others were detected by Dr. Leidy in the neighborhood of Philadelphia. Finally, we may mention several specimens of *Gordii* from Oregon, brought home by the United States Exploring Expedition. *Gordii*, therefore, are spread all over the Western Hemisphere.

The mode of development of our common *Gordius varius* (Plate LXIII, Fig. 6, *h*), has been studied by Dr. Leidy.† This is quite a different species from *Gordius aquaticus*, the end of the body of the female being trifurcated, while that of *G. aquaticus* is blunt. It is from 4 to 12 inches in length, and appears to be much slenderer than *Gordius aquaticus*. "The *Gordius varius*," says Leidy, "is prolific in a very remarkable degree." A female 9 inches in length placed in a tumbler of water extruded a string of ova 91 inches in length, in which he estimated there were over 6,000,000 eggs. Dr. Leidy saw the eggs undergo the process of segmentation. On the third day, the germ appeared as an "oval, finely-granular body," and by the tenth day the embryo was conical in form, with a cleft or fissure which extends two-thirds the length of the mass. Upon the eleventh day it resembled a cylinder doubled upon itself, and the tail-end was subacute.

> From the nineteenth to the twentieth day the embryo alternately retracted and protruded the tentacular or filamentary appendages, and the integument of the anterior

* Proc. of the Academy of Natural Sciences, Philadelphia, v. 1850 and 1851, p. 279.
† Proc. of the Academy of Natural Sciences, Philadelphia, v. 98 and 262, 1850 and 1851.

half of the body appeared to be getting annulated, which was so by the twenty-first day. * * * On the twenty-second day the annulations of the anterior half of the body were very distinct, the posterior half was also becoming annulated, and near its extremity I for the first time observed an anal orifice and one to four small epidermal spines. On the twenty-fourth day, the tubular clavate organ before mentioned, occupying the anterior part of the alimentary canal, was alternately protruded and retracted as a proboscis. The proboscis, when fully protruded, brought into view at its base a second circle of tentacular filaments within the first. On the twenty-sixth day the embryo, when pressed from the egg, progressed forward by moving the posterior half of its body from side to side, and it alternately protruded and retracted the proboscis and the two circles of tentacular filaments. When all the organs were retracted the head presented a truncate or depressed surface, and in their protrusion the extremities of the outer circle of tentaculæ and the end of the proboscis first became visible; as these advanced, the second circle of tentaculæ appeared, and when the proboscis was entirely protruded, the outer tentaculæ were deeply reflected upon the outside of the body, and the inner circle projected obliquely outward and upward. (See also Leidy's figures and description in the American Entomologist, ii, p. 196.)

It is evidently this species whose habits Dr. Leidy further describes in his "Flora and Fauna within Living Animals."* I quote as follows from this work:

The grasshoppers in the meadows below the city of Philadelphia are very much infested with a species of *Gordius* probably the same as the former, but in a different stage of development. More than half the grasshoppers in the locality mentioned contain them; but those in drier places, as in the fields west and north of Philadelphia, are quite rarely infested, for I have frequently opened large numbers without finding one worm.

The number of *Gordii* in each insect varies from one to five, their length from 3 inches to a foot; they occupy a position in the visceral cavity, where they lie coiled among the viscera, and often extend from the end of the abdomen forward through the thorax even into the head. Their bulk and weight are frequently greater than all the soft parts, including the muscles, of their living habitation. Nevertheless, with this relatively immense mass of parasites, the insects jump about almost as freely as those not infested.

The worms are milk-white in color, and undivided at the extremities. The females are distended with ova, but I have never observed them extended.

When the bodies of grasshoppers, containing these entozoa, are broken and laid upon moist earth, the worms gradually creep out and pass below its surface. Some specimens which crawled out of the bodies of grasshoppers and penetrated into earth contained in a bowl, last August, have undergone no change, and are alive at the present time (November, 1852).

In the natural condition, when the grasshoppers die, the worms creep from the body and enter the earth, for, suspecting the fact, I spent an hour looking over a meadow for dead grasshoppers, and, having discovered five, beneath two of them, several inches below the surface, I found the *Gordii* which had escaped from the corpse.

Some of the worms put in water lived for about four weeks, and then died from the growth of *Addya prolifera*. What is their cyclical development?

The history of the *Gordius aquaticus* has been mostly cleared up by A. Villot,† and the following account is condensed from his memoirs:

The eggs (Plate LXIII, Fig. 7, *a*) are laid in long chains; they are white, and excessively numerous. The yolk undergoes total segmentation. (Plate LXIII, Fig. 7, *b*.) At the close of this period, when the yolk is surrounded by a layer of cells, the germ elongates at what is destined to be the head-end, this layer pushes in, forming a cavity, and in this state it is called a "gastrula." (Plate LXIII, Fig. 7, *c*.) By this time the embryo becomes pear-shaped (Fig. 7, *d*); then it elongates. Subsequently the internal organs of digestion are formed, together with three sets of stiff, spine-like appendages to the head, while the body is divided by cross-lines into segments. The head lies retracted within the body. (Fig. 7, *e*.)

In hatching, it pierces the egg membrane by the aid of its cephalic armature, and escapes into the water, where it passes the early part of

*Smithsonian Contributions to Knowledge, v. 1853.

†Monographie des Dragonneaux (Genre *Gordius* Dujardin), par A. Villot. (Archives de Zoologie expérimentale et générale, tome 3, No. 1, 2, 1874, Paris.)

its life. Plate LXIII, Fig. 7, *f*, represents the embryo of *Gordius aquaticus* greatly magnified. It will be seen how greatly it differs from the adult hair-worm, having in this stage some resemblance to the *Acanthocephalus* by its cephalic armature, to the *Nematoidea* or thread-worms by its alimentary canal, and to the larvæ (*cercaria*) of the *Tremotodes* or fluke-worms in the nature of its secretory glands. But the hair-worm differs from all these worms and even *Mermis*, a hair-worm much like and easily confounded with *Gordius*, in having a complete metamorphosis after leaving the egg.*

When in this stage, it incessantly protrudes and retracts its armed head, the spines being directed backward when the head is out.

In the first period of larval life the worm lives encysted in the bodies of aquatic fly-larvæ. The vessel in which M. Villot put his *Gordius* eggs also contained the larvæ of *Tanapus*, *Corethra*, and *Chironomas*, small gnat-like flies. He found that each of these larvæ contained numerous cysts with larvæ of *Gordius*. He then removed the larvæ from the cysts, placed them on the gnat-larva, and saw the larval hair-worm work its way into the head of the gnat-larva through the softer part of the integument; during the process the spines on the head, reversing their usual position, enabled the worm to retain its position and penetrate farther in. Then, finding a suitable place, it came to rest and remained immovable. Then the fluids bathing the parts coagulated and formed a hard, granulated sac. This sac at first closely envelopes the body, then it becomes looser and longer, the worm living in the anterior part, the front end of the sac being probably never closed. In this first larval state the worm is active.

In the second larval period the young hair-worm lives motionless and encysted in the mucous layer of the intestines of small fish, which prey on the gnat-larvæ. A minnow, for example, swallowing one of the aquatic gnat-larvæ, the encysted larva becomes set free by the process of digestion in the stomach of the fish; the cyst dissolving the young hair-worm itself becomes free in the intestine of its new host. Immediately it begins to bore, aided by the spines around the head, into the mucous membrane lining the inner wall of the intestine of the fish, and then become encysted, the worm itself lying motionless in its new home, with its head retracted and the tail rolled in a spiral. The cyst is either spherical or oval. (Plate LXIII, Fig. 6, *g*.)

The return to a free state and an aquatic life occurs in the spring, five or six months after the second encystment. It then bores through its cyst, and passes into the intestinal cavity of the fish, and from thence is carried out with the fæces into the water. On contact with the water great changes take place. The numerous transverse folds in the body disappear, and it becomes twice as long as before, its head-armature disappears, the body becomes swollen, milky, and pulpy. It remains immovable in the water for a variable period, and then increases in size, the integument grows harder, and when about two inches long it turns brown and begins to move. Probably the host differs according to chance. Most of those which have occurred in Europe reside in

* It may here be said that in the *Mermis* hair-worm, which also lives in insects, and is of the same general appearance as *Gordius*, the young when hatched is not annulate, has no cephalic armature, while the body is short and thick, the tail blunt. These remarks are based on some drawings of the eggs and embryos of a *Mermis* made by Mr. James H. Smerton, in Jena (May, 1876), and kindly given me by him. The female genital apperture is situated in the middle of the body, while it is placed at the end of the body in *Gordius*, leading out of a cloacal chamber in which the intestine and two different ducts (male or female, as the case may be) terminate, the common external aperture being ano-genital in its nature.

carnivorous beetles, such as different species of *Carabidæ*. They live in or around the fat body, and sometimes twine around the intestines of their host, and finally pass out of the anus. As the carnivorous insects are liable to devour the larvæ of other insects living in damp places, it is not difficult to see how they should become tenanted by young hair-worms encysted in their victims, but why they should be so common in grasshoppers is not so easy to determine. Grasshoppers probably take the minute larvæ with their food, and fields recently inundated are of course more liable to abound with them. They also live in fish and frogs, and "Diesing speaks, on the authority of Kirkland, of a young girl in Ohio who had expelled *per ano* a *Gordius varius*. It is the popular belief in Europe that they live in man, and that they may be introduced in drinking water from brooks and pools, or in eating fish not properly cooked. In this country they seem to occur not uncommonly in the bodies of grasshoppers, and are useful in keeping them in check.

Description of the species occurring in the United States.—The following descriptions are taken from Villot's Monograph, and embrace all up to this time known to inhabit this country, a few notes of my own being added:

Gordius aquaticus Linn (Plate LXIII, Fig. 7, *a*, *f*, *i*, and *k*).—Anterior end rounded, distinctly swollen. Posterior extremity of the male bilobate, recurved beneath; lobes distinctly hollowed within and abundantly provided with papillæ; a crescent-shaped fold of the epidermis beneath the ano-genital opening. Posterior extremity of the female truncated perpendicularly to the axis; ano-genital opening central, surrounded with a reddish-brown circle. General coloration varying from milk-white to brown; a horny, transparent cap and a deep-brown ring at the anterior extremity; body besprinkled with numerous circular spots of a yellowish-white. Epidermis smooth, divided into lozenges by salient lines crossing obliquely. Dimensions very variable; length, 28–89 centimeters; breadth, ½ to 1 millimeter.

Habitat: Europe and North America (Leidy and Girard). A male of this species from *Gryllus neglectus* June 5, Pittsburgh, Pa. (B. C. Jillson), and a female from Topsfield, Mass., are in the museum of the Peabody Academy of Science at Salem. I have received a female of this species from Prof. C. V. Riley, said to have been a parasite of *Caloptenus spretus* in Missouri. It is probably common all over the country east of the Rocky Mountains.

Gordius lineatus Leidy.—Posterior extremity of the female obtuse; that of the male bilobed and furnished with papillæ. Length, 5 to 7 inches. (Leidy). Essex County, New York. Diesing cites it among the synonymes of *Gordius aquaticus*.

Gordius robustus Leidy.—Posterior extremity a little compressed and obtuse. Body stiff, marked with transverse folds 6 inches long. Pemberton, N. J. From a grasshopper (Leidy). Diesing refers it to *Gordius aquaticus*. A female which agrees with this species, from the body of *Stenopelmata fasciata* Thomas (identified by Mr. Thomas), Wahsatch, Utah (L. E. Ricksecker), is contained in the museum of the Peabody Academy of Science. The posterior extremity is compressed, except at the extreme end, which is cylindrical. The ano-genital orifice is sunken. The body appears as if irregularly segmented, being marked by transverse, impressed lines. Head conical, more acute than in *aquaticus*, and paler. This specimen was 10 inches long, of the same size and proportions as *G. aquaticus*, and would at first be mistaken for it.

Professor Leidy states in the American Entomologist (ii, 194) that a female of this species, about 6 inches long, was found parasitic in a grasshopper, *Orchelimum gracile*, in New Jersey.

Gordius subspiralis Diesing.—Body of the male brown; that of the female attenuated in front, of a clear brown, brilliant, irised. Head surrounded with a ring of an obscure brown. Caudal extremity of the male terminated by two diverging lobes, spiral, recurved beneath, smooth, joined to their base by a membranous fold; that of the female obtuse, a little compressed. Dimensions of the male: Length, 8 inches–2 feet 2 inches; thickness, $\frac{1}{4}$–$\frac{3}{5}$ of a line; female, 10 inches–2 feet 6 lines; thickness, $\frac{1}{3}$–$\frac{3}{5}$ of a line.

Habitat: Common in a pond 525 miles west of Fort Riley, Kansas, which would place the *habitat* in Central Colorado, where it lives in company with *Siredon* (Hammon). Diesing, who made the species known in 1860, referred to it a *Gordius*, which Leidy had mentioned without a specific name in 1857.

Gordius fasciatus Baird.*—Body furrowed with cross-lines, attenuated in front and

* Proceedings Zoölogical Society London, 1853, 21, pl. xxx, f. 6.

surrounded with circular wrinkles of a bright brown, besprinkled with broad spots of an obscure brown; extremities of the body blackish. Length of the female, 11½ inches; thickness, about one-half of a line. North America, British Museum.

Gordius reticulatus Villot.—Anterior extremity ending in a sharp point. Diameter of the body increasing from the anterior end to the posterior extremity, which terminates in a truncated point. Ano-genital aperture broad. Maroon-brown. A dorsal and ventral band of a darker brown. Epidermis areolated; areoles forming a net-work, with irregular and unequal meshes, having a mean diameter of 10 millièmes of a millimeter. A simple border of small papillæ around the areoles. Length, about 14 inches; thickness, 1 millimeter. California, Museum of Paris (a single individual).

I have identified a specimen of this species from California, sent by Mr. Henry Edwards to the Museum of the Peabody Academy of Science.

Gordius varius Leidy (Plate LXIII, Fig. 6, *h*).—Body very long, filiform, attenuated at each extremity, especially at the anterior; of a dirty-white yellowish-brown, also very black, shining, areolated, areoles irregularly pentagonal. Head surrounded with an obscure brown or black ring, obliquely truncated and terminated by a transparent cap. Mouth situated at the base of this cap. Posterior extremity of the male reflected, terminated by two conical, recurved, obtuse, and divergent lobes.* Posterior extremity of the female trilobed, lobes almost elliptical, of which one is straighter than the other. Length of male, 4–6½ inches; thickness, $\frac{1}{6}$–$\frac{1}{4}$ of a line; length of a female, 5–12 inches; thickness, $\frac{1}{4}$–$\frac{2}{5}$ of a line.

Habitat: Very common in the rivers of North America (Rancocas, Augusta, Schuylkill, Delaware). Observed, also, in the Niagara by Agassiz; in the Susquehanna and Lake Champlain by Baird.

The American species of Mermis.—Although the genus *Mermis* is very similar in external appearance to *Gordius*, it differs greatly in internal structure, and in the embryo being unarmed and not undergoing a metamorphosis. The species, however, are parasitic in various insects. I quote the following generic characters from Carus's Hand-Book of Zoölogy, giving a free translation for the use of the American student:

Gordius.—Head without papillæ; a short æsophagus opening into the cellular contents of the body; male with forked tail; genital opening between the forks; no spiculum, but with spines; female opening on the end of the tail, entire, two or three pointed; without any lateral expansions (seiten felder).

Mermis.—Head beset with papillæ; a long œsophagal tube sunk in the cellular contents of the body (intestine?); male with an undivided tail-end, with several rows of papillæ and two spiculæ; female genital opening in the middle of the body, with lateral expansions.

In both genera the intestine ends in a blind sac, there being no anus.

Mermis elongata Leidy.†—Yellowish-white, and from 6 to 8 inches in length. New Jersey.

Mermis crassicaudata Leidy.‡—Pure white, with a peculiar tubercular thickening of the integument upon the caudal extremity, 8 inches in length. Philadelphia.

Mermis acuminata Leidy.§—Female. Body filiform, pale fuscous, narrower anteriorly. Head conical, truncate, with the mouth simple and unarmed. Caudal extremity thicker than the head, obtusely rounded, and furnished with a minute spur-like process Length, 5 inches 8 lines; cephalic end at mouth, $\frac{1}{12}^{mm}$; a short distance below, $\frac{1}{6}^{mm}$. middle of body, $\frac{3}{8}^{mm}$; near caudal end, $\frac{1}{4}^{mm}$; mucro, $\frac{1}{12}^{mm}$ long, $\frac{1}{80}^{mm}$ thick. Parasitic in the larvæ of the coddling moth (*Carpocapsa pomonella*), Philadelphia and Long Island, N. Y. Professor Riley informs me that he had previously to the publication of Professor Leidy's article found a hair-worm in the body of a coddling worm. Professor Leidy has observed a white hair-worm (*Mermis* sp.?) proceeding from the Carolina grasshopper, *Oedipoda carolina* (Linn.), while the latter was struggling in a ditch into which it had jumped from being alarmed. Perhaps in this way we may account for the occasional appearance of a *Gordius* in a drinking-trough or a puddle on the road. (Amer. Ent., ii, 195.)

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* In his article, "The *Gordius* or hair-worm" (American Entomologist, ii, 193, 1870), Professor Leidy describes, under the name of *Gordius longilobatus*, a form which he regards as a distinct species, being slenderer than the true *varius*, with the forks of the tail two or three times the length of the thickness of the body, and the forks do not include at their base a crescentic fold, as in the former. The genital pore is a little in advance of the division of the tail.

† Proceedings Academy of Natural Sciences, Philadelphia, 1852, v, 263.

‡ The same, p. 263.

§ Proceedings Academy Natural Sciences, Philadelphia, 1875, 14.

REMEDIES.

The locust may be most effectually dealt with while in the egg-state. Bounties should be paid by the different States and Territories, as is done by European governments. As the eggs are laid very close together and only an inch beneath the surface, the top soil might be gathered into heaps and heated through by bonfires, or passed through crushing mills, or the egg-sacs picked out by women and children and liberal bounties be paid—so much a bushel—by town or county inspectors, and then burned. Deep plowing and heavy rolling are very advisable, and, on the other hand, harrowing the field in autumn so that the egg-sacs may be turned up and exposed to the frost and birds and hogs and cattle.

When the locust is still wingless it does the most harm, and can then be best kept within due limits. In Colorado and Utah, where irrigation is practiced almost entirely, fields can be flooded, the ditches can be oiled, and myriads be destroyed. Oil or any greasy substance is the best remedy in dealing with any insect, as it should be remembered that insects do not breathe air through the mouth, but inhale it through small openings (spiracles) in the side of the body; if these holes are covered with a thin film of oil or grease of any kind, they die at once. By taking energetic measures; the farmers of Colorado, as will be seen by Mr. Byers's letter on p. ——, in the spring of 1876 effectually destroyed the young brood. Fowls should also be turned among them; the soil should be rolled so as to crush them, and trenches dug and filled with straw and set on fire and the locusts driven into them with switches, or prairie-fires be lighted in a circle around them, and the locusts driven into them.

In Colorado a great deal of ingenuity has been evinced in dealing with the locust, as may be seen in reading the two following extracts from the newspapers, which contain some useful practical remedies:

This is how the embattled farmers of Colorado deal with the grasshoppers: A long sheet-iron box, open at the top, is swung close to the ground, between two wheels, by which it is moved over the field. Rising two or three feet above the top of the box, and bending forward from the rear, is a broad sheet of tin or sheet-iron. When in use a fire is built in the bottom of the furnace, which is then pushed against the wind, the overhanging wing or sail taking the hoppers as they rise, and feeding them in the flames in a hurry. Sometimes a miniature windmill is added to the outfit, and sucks in all the locusts for yards and yards around, destroying them by millions. Millions more have been drowned in irrigating ditches by cunningly-devised traps which prevent their escape from the water. While they were young and green, and before their wings were grown, several tons of them were destroyed by a confidence game which deserves description. Between the young hoppers and the young wheat long rows of dry straw were strewn, which soon became literally black and alive with the wriggling little insects. When no more hoppers could be accommodated, the straw was fired. Another device was to drag over the hopper-infested regions a tarpaulin plentifully coated on the under side with coal-tar, which is instant death to the pests. Still, with all these disadvantages against them, grasshoppers are apparently as numerous as ever.

The farmers of Colorado are busily fighting the grasshoppers, which have appeared in immense swarms. A letter from Denver says they "sluice them down the ditches with water, gather them up in heaps and burn them; for the water will only collect, and not drown, these very vital pests. They set cans of oil, dripping slowly, at the heads of their ditches, and the slightest touch of the oily film, floating down with the running water, destroys the young grasshopper. They drag the ground with huge harrows, covered with blazing brush, and the flame scorches its tiny millions to death. They draw papers or platforms smeared with tar along the fields, and the insects, trying to hop over, fall on the tar and stick there. With all these devices they only thin out the unwelcome visitors.

The following pertinent remarks I find in an editorial in the Rocky Mountain News, November 22, 1876:

The farmers of Colorado have demonstrated the fact that they can successfully combat and conquer the young grasshopper. They undertook the fight with extreme re-

luctance, but won the victory with less than half the trouble they expected. Only those who feared to plant last spring, or those who planted so late that the flying swarms in August caught their unripened grain, are now mourning the lack of good crops. If they now had information that grasshopper-eggs are deposited plentifully in Laramie Plains, the Sweetwater Country, or Upper Green River Basin, none would plant late next spring. All crops would be put in early and harvested in July, because they would know that if swarms of grasshoppers hatch in any of the regions named, next spring the prevailing winds will be likely to bring their devouring hosts down upon Colorado about the second week of August. But we do not know whether any egg-laying swarms invaded those countries in August, September, or October last or not. So far as that matter is concerned, we are just as ignorant this year as we were in the fall of 1863 prior to the first and most astonishing invasion of August, 1864. Consequently, half the farmers, instead of planting in February and March, will put it off until May, and then trust to luck. If no grasshoppers come, all right; if they do come and eat up the barley and wheat in the milk and the corn when the tassels are shooting, they'll curse the country and their own hard fate—laziness.

Although no one can tell now with present light, or rather darkness, whether or not flying swarms of grasshoppers are *likely* to scourge Colorado next fall, we are all pretty certain that we will have plenty of young ones in the spring, and that some other country will get them "on the wing" in the fall. It will probably be Southern Kansas, Indian Territory, or Texas. They may reach Southwestern Missouri or Arkansas. Consequently, the News advises the people in that direction to plant early and mainly of crops that will be harvested by the 20th of July. The grasshoppers that hatch here will fly two or three weeks earlier than those from higher latitude and altitude.

The farmers of Colorado in 1876 were quite successful in combating the locust. The best account of their mode of fighting them appears in the New York Tribune, from the pen of Mr. J. Max Clark, of Greeley, Colo.

Indeed, notwithstanding those natural barriers to their progress eastward—climate and soil—it is hardly safe to assert that they may not yet reach much farther into the older States than they have heretofore succeeded in penetrating. It is true they thrive best in a dry climate, but they can exist and perpetuate themselves in a wet one; they prefer a dry sandy or gravelly soil in which to deposit their eggs, but the conditions not being so favorable they will lay them in heavy wet soil, with no apparent injury to their vitality. They have been known to hatch in this vicinity on the margin of a lake, in soil almost marshy in its texture. I have myself known them to come forth in an apparently perfectly healthy condition from soil too wet to plow.

While, for the reasons set forth, we can have no great faith in any method of general destruction, there are means of defense which at times are very effective, and which are always worth trying. In this State our main reliance is on water. We surround our fields with ditches, and into the water we drop kerosene oil, which covers the surface and kills the young grasshoppers at the touch. When they deposit eggs in the fields, as they frequently do, we watch for their hatching and scatter straw over them as they come out of the ground, and burn them if possible before they get scattered. When young grasshoppers attack a crop they generally do so in a compact body, much in the form of a line of battle, and for a short time at least after striking the vegetation do not scatter, but eat the border clean as they go. At such times they are easily destroyed, and any farmer who has straw stacks and teams can, if quick and energetic, generally save his crop by spreading straw on the advancing line and burning them. When grasshoppers have invaded a field of young grain, or have hatched in it, and have become scattered through it before they have been discovered, then another line of policy must be pursued, and one not so certain of success. We use a fire-machine, which may be described as being a net-work of heavy wire (telegraph-wire is good) upon runners of iron about 4 inches high, upon which straw, coal, or wood is burned as the machine is drawn by horses attached to long rods, meeting at a point 15 or 20 feet in advance of the machine. The machines vary in width from 8 to 12 feet in their sweep, and are about 3 feet deep from front to rear, with a sheet-iron cover attached to the rear and raised from 1 to 2 feet high in front to throw the flames downward through the net-work of wire as the machine proceeds. This kills the young hoppers without generally seriously injuring the grain.

We also use a platform of zinc or canvas, or even thin boards from 6 to 10 feet long and 3 feet wide, upon which is spread coal-tar with a broom or whitewash-brush, from a pailful of liquid ready for the purpose. This is dragged by hand or with a horse. The runners under the platform are only a couple of inches in length, and the hoppers jump on to the tarred surface and stick fast as the machine is moved along. This is a very simple contrivance, and is generally regarded as about as effectual as the fire-machines, while not costing nearly so much in construction or for running-expenses.

Kerosene oil is a valuable agent whenever it is practicable to use it, both to destroy the grasshoppers and to prevent their depredations. A spoonful of oil, kept well shaken up in a watering-pot filled with water, and sprinkled upon melon-vines, squash-vines, or any other garden vegetables, will effectually prevent their destruction. It is a cheap means of defense and easily applied on a small scale. Various methods are in use for the destruction of the eggs where they are known to be deposited. Deep fall or early spring plowing has a tendency to disturb and destroy them, sometimes wholly and sometimes only in part, but always seriously affecting their vitality. A flock of sheep having the run of a stalk-field of mine last season completely destroyed a large deposit of eggs. The ground was very loose and dry, and the surface becoming completely pulverized and cut up with their feet, not one of them ever hatched. Birds are an important aid in their destruction, and in loose soils they scratch out and eat enormous numbers of them. The much-despised skunk, too, is a most desirable friend to man in this contingency. A single skunk will often clear an acre of ground, even in sod, of all grasshopper-eggs. No farmer in the West who has good sense will kill skunks. They deserve to be propagated, even if it were necessary to nurse them on young chickens.

To defend a field of grain against flying grasshoppers, altogether different tactics must be employed. Clouds of dense smoke made from burning old rags wet with kerosene oil, or by burning coal-tar or sulphur in differint parts of the fields, have proved quite successful when thoroughly tried. Sometimes also they may be driven from a field by dragging ropes through the grain, on which are tied newspapers or rags; when, however, they are tired with a long flight and are hungry from long fasting, this latter method is generally of little avail. In this State the young grasshopper is our worst enemy, our principal crop being wheat. The flying hosts seldom get here in time to injure it. When we came out here the old settlers told us they only had grasshoppers about once in seven years; that season being free from them seemed to lend weight to the statement. The next year bringing a pretty fair crop of them, they said they usually came every other year, but as we have had them every year since, they now say they generally stay about seven years in a place. Perhaps, after all, the "fourteen-year locusts" would be an appropriate designation; at least we look upon them as being a permanent investment, and make our plans to fight them always. We have a fair amount of eggs planted for next year's crop.

In Iowa the farmers spread hay or straw over the surface. "At night the young insects would gather under it, and immense numbers were burned up in this manner. Plowing is resorted to this fall (1876) in some localities for the purpose of covering the eggs deep, by which it is said they will rot. Other methods have been used, such as catching them, and machines have been invented for this purpose. Rolling the ground in the spring had also been suggested as a means for destroying the young insects." (Proc. Conference of Governors.)

Some important suggestions of a practical nature are contained in the following proclamation of the governor of Minnesota, here reprinted from the Grasshopper Conference pamphlet:

STATE OF MINNESOTA, EXECUTIVE DEPARTMENT,
Saint Paul, August 30, 1876.

The continued and increasing ravages of the locusts or grasshoppers in many of the Territories and States of the Union have been deemed sufficiently serious to warrant a meeting of the governors of such States and Territories for consultation, with a view to seek congressional aid, or otherwise secure combined action in resistance of the growing evil. Such conference has been called to meet in October. Meantime the widening area of the visitations of these insects in this State induces me without delay to urge the people whose interests are most directly involved, to assemble in public meetings in their several localities, for the purpose of collecting information, interchanging views, and devising plans of concerted action for the destruction of the insects, and for a common defense against their ravages. Both the correction of exaggerated reports, and the promotion of an intelligent apprehension of the actual evil to be encountered, it is believed, would result from this course, while the hope of thus attaining practical means of mutual protection certainly justifies a united and energetic effort in behalf of an object common to the public welfare.

It is the concurrent belief of all who have given close attention to the subject that it is practicable to destroy the pests in great measure or to insure a vast mitigation of the worst results, by the timely, concerted, and persistent efforts of the several communities directly concerned, and the employment of simple agencies readily available. To this end I have taken pains to collect, from the most reliable sources, information of the several modes which have been successfully employed, which I here detail for the

consideration of all concerned, and I earnestly invoke the united and resolute action of the people in a manful defense against a common enemy:

First. The crushing of the insects by rollers and other implements, and the catching of them by bags and traps during the season of copulation or mating, when by reason of their stupid and inactive condition they may be destroyed in vast numbers. This is the first and vital step toward their destruction, and can be resorted to immediately, the insects being in the condition named from about the middle of August variously until the approach of cold weather.

Second. The plowing under deeply of the eggs and the thorough harrowing of the bare, dry knolls and other comparatively small, warm spots where the eggs are deposited, so as to dislodge them from their cells or pods, which destroys their germinating power. New breaking being a favorite resort for such egg deposits, this mode of destruction is readily available in the ordinary course of farm-work, for which purpose these operations should be delayed till as late a period in the fall as practicable.

Third. Co-operative action for the preservation of the prairie-grass until the proper season for its burning in the spring, by means of extended fire-guards along township boundaries or other large areas, to be accomplished by means of plowed strips or by wide parallel furrows and the careful burning of the intervening space. The burning of the grass thus preserved, when filled with the young grasshoppers in the spring, has been found to be a very effectual means for their wholesale destruction.

Fourth. The placing of loose straw on or near the hatching-places, into which the young insects gather for protection from the cold in early spring, where they may be destroyed by firing the straw at a proper time. To this end straw should be carefully saved and not needlessly destroyed at thrashing-time.

Fifth. The construction of deep, narrow ditches, with deeper pits at intervals, as a defense against the approaching insects in their infant condition. Into these the young, when comparatively helpless, accumulate in vast numbers and perish.

Sixth. The sowing of grain in "lands" or strips, fifty to one hundred feet wide, leaving narrow vacant spaces through which to run deep furrows and construct ditches into which the young grasshoppers may be driven and destroyed.

Seventh. The catching of the insects at various stages, and especially when young and comparatively inactive, by means heretofore employed, and by such improved instruments and processes as our experience may suggest.

Eighth. And, finally, the driving of the winged and matured enemy from the ripening grain by passing over it stretched ropes continually to and fro, aided by annoying smoke from burning straw or other smudges, and by loud and discordant noises made by striking tin vessels, and by shrieking and yelling with the voice, which are said to aid in disturbing the pests and inducing their flight.

Let the common enemy be thus fought at every stage of his existence and at every point of his attack. Each one of the modes here prescribed will doubtless aid to reduce the grand total of the annual destruction, while all of them, faithfully pursued in succession, together with other methods to be devised, it is confidently believed, will achieve substantial exemption from loss, or avert its saddest effects. But should all means fail, there will remain the consciousness of having made such helpful and assiduous attempts as deserved success.

The danger of weakening the habit of self-reliance among the people, as well as the difficulty of reaching the most worthy recipients of public aid, renders the distribution of seed-grain and other assistance heretofore extended to the sufferers of very questionable policy; and I feel it my duty to warn all persons against relying upon public aid of this character. Whatever action may be taken by the next legislature or by Congress should wisely contemplate future protection rather than indemnity for past losses, and, if practicable, should discriminate in favor of such as evince a disposition to help themselves. At all events, if aid or succor of any kind or from any quarter may reasonably be expected, it will be both better deserved and better employed after courageous and determined efforts shall have been made for self-protection.

J. S. PILSBURY, *Governor.*

At the grasshopper conference, Prof. C. D. Wilber made the following important suggestions regarding the remedial measures to be taken:

The objects sought to be attained by this meeting are two, viz:

1. The securing of national aid in prosecuting inquiries and research concerning the locusts in the distant or mountain regions, where they are said to originate, with a view of ascertaining such facts as may assist in exterminating them at their source or native haunts.

2. To discuss such plans as may be advisable in defending the localities now threatened by them during the coming year of 1877, or such regions as are now occupied by their eggs.

There is no doubt as regards the assistance sought for from the Government. The emergency is so great and applies to so many millions of inhabitants, and nearly one-

half of our commonwealth, that our representatives and governors and others in authority will all unite in obtaining the aid needed to prosecute the scientific research referred to.

The subject which most concerns us is the adoption of any or all the successful means already known, or such as may be provided, for a general and systematic crusade against locusts next year.

It is not certain that we shall have the impending invasion in 1877. They may wholly disappear, as they did from Iowa in the spring of 1867, without doing any damage.

Within the last thirty days I have examined many thousands of the eggs in South-eastern Nebraska, and find a large proportion already destroyed. Those in the hard ground, such as roadsides, are best preserved; while those in soft ground, such as stubble corn-fields, or gardens, are to a very great extent carried away or consumed by some predatory insect. But whatever the results may be in the spring, it is wise meanwhile to disseminate among the people everywhere descriptions of every known device or remedy, whether mechanical or chemical, by which we may secure partial, if not good, average crops. The people are generally uninformed on this subject; they do not know what to do. Arm them with reliable facts, modes of destruction, and we will have a home army of millions of men, who will fight vigorously for their farms and gardens.

Those who understand these matters in Nebraska have succeeded in driving off hordes of these locusts and saving their crops. Governor Furnas, who last year lost heavily by them, has now no fear either as to his farm or nursery. "He has met the enemy and they are his." His modes are exceedingly simple, as he has explained them. Another man in this same county raised one hundred acres of wheat by making a ditch as a barrier against the creeping, unfledged locusts; the ditch sloping to the coming hosts, but steep on the other side.

One man, in Saline County, invented a long box and placed it on wheels, so that it would catch all the locusts as it approached them. By this means he saved his corn-field.

Another man, in York County, burned brimstone in a large pan with a long handle, and drew it through his corn-field after the flying locusts had taken the country, and he was successful in saving his entire crop.

Again, the Mennonites came to Nebraska in 1874, and when they saw the first invasion of locusts in August of that year did not mind them in the least; nor have they manifested any concern or alarm since. The reason is, the Mennonites were familiar with them in Russia, and knew how to fight them successfully.

Some of their modes, in addition to cutting ditches, are as follows: In the spring, as the locusts begin to appear, they are driven, by pushing them with brush or brooms, to the grass or prairie, which is set on fire—that is, just that portion of the prairie which has received the horde from the plowed field. The prairie-fire is then put out; and as they appear day by day, more locusts are driven to the grass, which is also burned, and so on until all have been destroyed.

When the locusts are coming in swarms from abroad, the Mennonites build small smoke-fires, with dry or damp straw or prairie-grass, making fires at intervals of a few rods over a forty or eighty acre field. These fires or smokes are kept until the locusts have passed over, and in this manner the crop is wholly or partly saved.

But it is necessary to familiarize the people with these cheap and simple modes of destruction; and while much can be done through the press, much more can be done by organizing the counties, towns, and districts or precincts into locust clubs, under the authority or direction of the governor of each State or Territory, who may send some competent person or persons over the State to assist in perfecting such organizations and selecting the most available men as local committees, who can receive and distribute such printed matter as the governor may, from time to time, forward for distribution. In this way a whole State may be thoroughly organized for the campaign, and the entire population will become enthusiastic in preparing for and carrying on this warfare.

For other useful hints and suggestions the reader is referred to an article "On the means of destroying the grasshopper," by V. Motschulsky, translated from the Russian by Prof. W. W. Turner, and published in the Smithsonian Report for 1858.

It has also been shown that the most young may be destroyed by good cultivation and a constant stirring of the soil. Swarms of winged locusts may be in part driven off by smudges, or in grain-fields by hitching a long rope to a horse and dragging it over the grain, thus disturbing the locusts and driving them off. But after all they are only driven from one field to another, and it is almost impossible to drive

them off on an extensive scale. Among the more general preventive measures to be adopted on the plains and prairies of the West is the planting of forests on as extensive a scale as possible. Farms should be hedged in with growth of coniferous trees, willows, and perhaps the *Eucaliptus* can be planted on the plains of Colorado, Montana, and Dakota, while hard and pine trees can be planted in the State eastward of the plains. Mr. G. M. Dawson has clearly brought out the fact that extensive forests prove an effectual barrier to the flight of locusts, and in the Eastern States as well as California grasshoppers do not swarm as they do in the treeless plains and prairies of the West, the main cause, next to the climate, being undoubtedly the prevalence of extensive forests. As the far West becomes more thickly settled and trees become planted, the ravages of the locust will be checked and their breeding places disturbed and diminished. Meanwhile it may be suggested that the State and General Government should foster the planting of forests along railways and highways, and bounties should be given to aid in this direction. Farmers should co-operate through the medium of their granges and other organizations. Moreover, we believe the time has come in this country for legislation to promote co-operation among agriculturists in dealing with the locust, army and cotton worm, chinch-bug, canker and tent worms, and other injurious insects. The active and forehanded do not need the stimulus of legislation, but there are always enough idle and thriftless members of a farming as well as any other community who ought to be compelled to labor in common with their neighbors in resisting the attacks of injurious insects. When in one season, as in the summer of 1874, the country loses $50,000,000 from the attacks of the locust alone, the matter is sufficiently grave to attract the attention of legislatures. If education is compulsory and vagrancy is a legal offense, surely want of co-operation on the part of the few should be punishable by law. In my first annual report on the injurious and beneficial insects of Massachusetts, for 1871, I made the following suggestion in this direction:

> While a few are well informed as to the losses sustained by injurous insects, and use means to ward off their attacks, their efforts are constantly foiled by the negligence of their neighbors. As illustrated so well by the history of the incursions of the army-worm and canker-worm, it is only by a combination between farmers and orchardists that these and other pests can be kept under. The matter can be best reached by legislation. We have fish and game laws; why should we not have an insect-law? Why should we not frame a law providing that farmers, and all owning a garden or orchard, should co-operate in taking preventive measures against injurious insects, such as the early or late planting of cereals to avert the attacks of the wheat-midge or Hessian-fly, the burning of stubble in the autumn and spring to destroy the joint-worm, the combined use of proper remedies against the canker-worm, the various cut-worms, and other noxious caterpillars? A law carried out by a proper State entomological constabulary, if it may be so designated, would compel the idle and shiftless to clear their farms and gardens of noxious animals.

State legislation has also lately been agitated by the Massachusetts Horticultural Society.

A large proportion of the breeding-grounds of the locust are situated on the Indian reservations. Could not the Indians be compelled to search for the eggs and bring them in to the Government posts and be paid in food and clothing? It would not, perhaps, be a difficult matter to compel them to collect both eggs and winged locusts, under the direction of Government officials, and thus habits of industry be fostered, and additional inducements thus be held out to keep them on their reservations.

Locusts may also be eaten as food. Millions of people in the Old World find locusts a nutritious and palatable diet; why should not the

Indians be induced to eat them? In times of famine could not the settlers be brought to store them up and eat them? From the writer's own experience locusts may be roasted and eaten with somewhat of a relish, and Professor Riley in his entomological reports has discussed this subject at length.

It is stated in the Bulletin Mensuel de la Société d'Acclimation, (August, 1875), that Dr. Morran, a physician at Douarnenez, in Finistère, has thought of utilizing the African locust as bait for the sardine-fishery in the maritime districts of the coast of Mancha and the Atlantic Ocean. The doctor hopes to substitute this new bait for that employed until now under the name of roe (rogne), and the price of which, always increasing, is injurious to the interests of French fishermen. The locusts cooked in salt water are dried in the sun and ground. The powder obtained seems to make as good bait as roe. It has a dark color like that of the pickled roe of Norway. It preserves all the nutritive qualities of the locust. It re-absorbs the pickle, and is fatty, unctuous, and soft to the touch. Besides, it falls to the bottom of the water, resembling the flesh of craw-fish, comminuted and dried fish, of which the sardines are very fond. The insect can be put up in different ways, as made into biscuit, pickled, salted, pressed, or dried in the sun. Different methods of preparation have been tried; cooked and salted, the insects can be piled up in cakes, so as to be easily packed and transported. They can also be thrown alive, pell-mell, into brine and pressed. The first of these methods is employed by the Arabs. The Society of Agriculture of Algeria recommends smothering the locusts in soes, then drying in the sun. The bait prepared in these different modes has been tried at Douarnenez with good results. The sardines bit at them eagerly. It appears that in the bodies of a great number of sardines there have been found on examination the remains of locusts which the fish had swallowed. This last fact, stated officially, has well satisfied the maritime population of Douarnenez.

This, possibly, opens up a new industry for the inhabitants of locust-ridden districts in the West, who can put up in locust-years large quantities of bait for the market East.

CONCLUSIONS.

In conclusion, we believe that the locust-years may in the future be predicted by our meteorologists, and Government attention should be directed to this subject, and special consideration on the part of our Weather-Signal Bureau and meteorologists should be given during the future to the study of meteorological cycles. Years of unusual heat and dryness, which are forerunners of locust invasions, may, we believe, in the future be predicted, and farmers warned, while State laws provide that in years of plenty, at least in the frontier States, stores of grain be amassed for a year of famine. Thus, by the predictions of locust-years, by the planting of forests, and the free use of the telegraph in heralding their migrations, and the publication in the newspapers of daily bulletins of their direction and progress, and when they are present the enforcement of territorial and State laws, as well as bounties for the eggs and young, we believe that millions of property will be saved to the country, and the intelligence and wisdom of the American people be evinced in the truly agricultural as it already has in the mechanical arts.

SUMMARY OF OUR PRESENT KNOWLEDGE OF THE LOCUST.

1. The eggs are laid an inch below the surface of the ground in July, August, and September, as the latitude varies; and the young hatch in April and May, becoming fledged in about seven weeks from early in June until the last, swarming from the first of July until last of September. Birds and insects eat the eggs and young, and a mite, Tachina fly, and hair-worms infest the adults.

2. While the Rocky Mountain locust occurs permanently on the eastern slope of the Rocky Mountains, on the high, dry plateaus between 4,000 and 7,000 feet elevation, the district liable to its periodical invasions is between latitudes 30° and 52°, and longitudes 102° and 93°. It occurs, though of smaller size, in California and New England, and probably in British America from the Atlantic to the Pacific.

3. Its migrations take place at irregular intervals during or after hot or dry seasons, when immense swarms are borne from the Rocky Mountain plateau by the prevailing westerly and northwesterly winds, sometimes 500 or 1,000 miles, into British America, Minnesota, Nebraska, Kansas, Missouri, and Texas, where they lay their eggs.

4. The progeny of the emigrant swarms return the following season in a general northwest direction for at least hundreds of miles, to near the original habitat on the plains.

5. The periodical invasions may after a while be predicted with more or less certainty should Government take measures to appoint suitable persons to observe them, or delegate the task to the Weather-Signal Bureau; meanwhile, by the use of the telegraph, the arrival of swarms may be announced several days in advance.

6. In years of plenty in the border States and Territories, grain should be stored up for use in locust-years.

7. Preventive measures, such as planting of forests along lines of railroads, around towns and extensive farms; the use of irrigation, oiling ditches and canals, bonfires and prairie-fires, rolling the soil, and collection of eggs; bounties to be paid by Government in the Territories, or by the local authorities in the States infested, for the egg-sacs.

8. Co-operation among farmers and others in resisting the attacks of insects to be enforced by proper legislation, both in the Territories and border States.

9. We still need more light on the natural history and migrations of the locust, and the United States Government should appoint entomologists, who should study the locust comprehensively for several years in succession. Local entomologists should be appointed for each Territory, and the border State legislatures should appoint salaried entomologists to further study and report on the locust, and serve for a term of years until the entire subject be studied, and the knowledge thus acquired be freely diffused among the agricultural community.

FURTHER INFORMATION NEEDED.

It may be found on subsequent examination that some, if not many, so-called facts and inductions from such facts given in this report are erroneous. Indeed, regarding the laws regulating the migrations of the locust, the greater the number of facts observed, and the greater the area of observation, the less certain seem the opinions already formed by entomologists. Repeated observations by reliable entomologists and the careful sifting of facts recorded by unscientific observers are needed

before we can decide what is true and what is erroneous in the published accounts of the western locust.

The following points need to be especially studied and cleared up:

1. How early in the summer are the eggs laid in Minnesota?

2. The direction of flight and history of the newly-fledged swarms in Minnesota particularly, as well as in Texas and Indian Territory.

3. Is the supposed northwesterly return-flight of the locust from Nebraska, Kansas, and Missouri late in June an invariable occurrence, or do the swarms fly in other directions?

4. What is the fate of those early summer swarms; and (*a*) do they lay eggs in the region directly east of the Rocky Mountains, or (*b*) fly north into British America, or are they scattered on the plains midway between the border States and the Rocky Mountain plateau, and lay eggs for swarms which afflict the border States the following year; or (*c*) do they fail to reach favorable breeding-places and lay but few eggs?

5. The exceptions to the northwest direction of the migrations from the border States should be fully stated, and if there be such exceptions, the causes, local or meteorological, carefully inquired into.

6. Ascertain in Minnesota the length of time between the acquisition of wings and oviposition.

7. Make experiments on the vitality of the eggs. The eggs of the Europeo-Asiatic locust survive a temperature of —26° Fahr.

8. Do cold, wet springs and thawing and freezing late in the winter destroy the eggs?

9. Do the locusts always copulate immediately after acquiring wings?

10. Duration of the sexual act—(more than 20 minutes?)

11. How many times does the same female receive the male?

12. How many males will a single female receive?

13. How many females will a single male impregnate?

14. How many times does the same female lay eggs?

15. Does a female lay more than one packet of eggs?

16. Does a female lay more than one packet of eggs after a single impregnation?

17. State the average number of eggs laid in a packet.

18. State the number of days after copulation before the eggs are laid—(more or less than seven days?)

19. Does *Caloptenus spretus* copulate with other, and what, species; does it hybridize with other species, particularly *femur-rubrum*, or var. *atlanis?* Are the hybrids (if any are produced) fertile?

20. State observed (not estimated) rapidity of movement of swarms in the larval state, and whether they migrate in the morning or evening, or both?

21. After which molt do the young locusts begin to assemble in small flocks and mass with larger ones—after the first or second molt?

22. Do the young wingless locusts move and feed by night?

23. Do the swarms of winged locusts descend toward sunset, and at what time? At what time do they take wing in the morning?

24. Make careful observations as to the influence of the wind on their migrations. Are they wholly dependent on favorable winds to bear them on in the course they usually take, and do the locusts wait for favorable winds?

25. Ascertain western limits of *Caleptenus spretus*, and the range of its var. *atlanis*.

APPENDIX A.

Meteorological data afforded for this report by Bvt. Brig. Gen. A. J. Myer, U. S. A., Chief Signal-Officer.

Station and month.	1871.				1872.				1873.				1874.				1875.				1876.			
	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.
BISMARCK, MONT.																								
January	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	—8.89	49.11	N	6468	7.92	53.6	NW	5319.3
February	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	—5.88	59.25	N	5715	4.85	59.99	NW	5461.1
March	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15.29	59.94	SE	7512	13.06	56.75	N	6247.3
April	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	33.95	65.65	NW	8549	40.3	48.63	NW	6571.1
May	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	56.13	60.33	S	7480	56.0	51.6	SE	6280.5
June	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	60.88	60.87	E	6186	61.4	50.08	NW	6989
July	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	69.30	48.90	NE	5973	70.3	53.96	NW	5807.5
August	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	66.24	59.57	NW	5727	68.0	59.16	NW	6654
September	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	56.10	59.36	NW	5517.7	.....	.....	.....	.....
October	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	41.3	51.9	N	6203	42.73	63.06	NW	7598.8	.....	.....	.....	.....
November	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18.1	63.2	N	5742	17.15	61.51	NW	6109.2	.....	.....	.....	.....
December	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15.58	57.59	N	5884	20.08	61.21	NW	5801.5	.....	.....	.....	.....
BRECKENRIDGE, DAK.																								
January	.....	.....	.....	.....	.....	.....	.....	.....	2.3	.....	NW	11030	2.6	80.1	SE	11285	—9.48	81.85	NW	6437	6.35	53.18	SE	10053
February	.....	.....	.....	.....	.....	.....	.....	.....	8.6	.....	SE	10080	4.2	78.2	SE	8946	—7.94	80.21	NW	6889	4.3	77.5	NW	10574
March	.....	.....	.....	.....	.....	.....	.....	.....	16.4	.....	SE	11770	15.1	80.2	NW	11293	14.69	82.55	SE	11906	10.5	79.0	N	10418
April	.....	.....	.....	.....	41.0	.....	NW	.....	35.0	.....	N	9530	34.0	72.4	SE	9058	36.13	76.38	NW	8669	38.27	71.85	NE	10209
May	.....	.....	.....	.....	53.0	.....	SE	10074	52.0	.....	SE	7676	60.2	60.6	SE	9081	55.97	64.80	SE	8065	56.32	54.46	SE	10318
June	.....	.....	.....	.....	65.0	.....	SE	7530	69.5	.....	SE	7259	65.9	76.7	SE	8061	60.79	77.60	SE	8176	63.12	61.98	NW	10769
July	.....	.....	.....	.....	67.1	.....	SE	5710	67.6	71.0	SE	7146	70.2	71.8	S	6084	67.69	69.53	N	.....	70.92	64.26	SE	9993
August	.....	.....	.....	.....	65.1	.....	SE	5905	67.0	80.0	SE	7504	67.8	77.9	SE	5708	63.76	75.37	SE	6439	67.65	71.21	SE	11323
September	.....	.....	.....	.....	58.3	.....	SE	7435	49.1	75.0	NW	7522	57.7	71.4	S	6499	55.4	78.9	NW	.....	.....	.....	.....	.....
October	.....	.....	.....	.....	45.0	.....	SE	8810	38.2	66.8	NW	8734	43.8	74.5	NW	7650	42.04	67.9	N	7490	.....	.....	.....	.....
November	.....	.....	.....	.....	21.0	.....	NW	9390	23.4	78.3	N	8764	21.4	81.7	NW	6923	18.31	74.77	SE	8463	.....	.....	.....	.....
December	.....	.....	.....	.....	0.4	.....	NW	8620	8.0	83.3	SE	7889	12.8	83.9	NW	7415	18.05	79.14	NW	10914	.....	.....	.....	.....

Meteorological data afforded for this report by Bvt. Brig. Gen. A. J. Myer, U. S. A., Chief Signal-Officer—Continued.

Station and month.	1871.				1872.				1873.				1874.				1875.				1876.			
	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.
CHEYENNE, WYO.																								
January	.....	....	.....	.....	26.6	.....	NW	8743	24.6	.....	NW	8905	30.4	46.6	W	9239	12.5	66.3	W	8485	23.8	58.0	W	.....
February	.....	....	.....	.....	30.9	.....	W	8659	25.0	.....	W	7420	22.9	52.6	W	6028	25.6	63.2	W	9057	30.7	44.6	W	11531
March	.....	....	.....	.....	33.0	.....	NW	6935	39.7	.....	W	9313	28.9	55.2	W	6023	24.3	62.6	W	11984	26.8	65.6	NW	10100
April	.....	....	.....	.....	38.3	.....	W	8639	34.4	.....	NW	8015	39.0	50.3	W	6130	36.9	60.6	NW	11112	42.4	44.8	W	10043
May	.....	....	.....	.....	52.0	.....	N	7300	49.2	.....	W	6465	56.6	42.4	W	7588	54.7	42.5	W	9780	50.6	55.6	W	9259
June	.....	....	.....	.....	51.5	.....	W	6660	69.5	.....	W	5266	65.2	39.5	W	6408	63.7	32.7	W	9332	60.8	39.1	W	7878
July	.....	....	.....	.....	64.5	.....	W	6675	69.7	39.6	W	5584	71.8	43.4	S	6521	64.0	58.4	S	6094	72.3	35.0	S	8483
August	.....	....	.....	.....	65.1	.....	W	5786	69.2	43.1	W	5548	68.6	39.2	W	6621	63.2	52.0	NW	6382	66.5	38.0	NW	7870
September	59.0	....	NW	5560	55.6	.....	NW	5975	55.9	38.4	.....	5437	54.2	42.5	W	7374	56.0	57.3	NW	6425	.....	.....	.....	.....
October	46.0	....	W	8004	45.2	.....	NW	4973	42.5	47.0	W	6390	46.7	58.2	NW	6704	47.9	40.4	NW	8469	.....	.....	.....	.....
November	28.9	....	NW	7940	28.2	.....	W & NW	8276	40.1	39.2	W	7010	35.8	51.8	W	9215	30.3	62.9	W	7539	.....	.....	.....	.....
December	28.0	....	W	9830	23.4	.....	W	6306	27.6	54.1	W	5753	29.1	52.9	W	8618	33.4	51.4	NW	4049	.....	.....	.....	.....
COLORADO SPRINGS.																								
January	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	30.3	47.0	NW	5306	19.1	63.7	SE	5529	28.22	39.48	N	5133
February	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	25.5	63.0	N	4402	29.2	73.44	SE	4126	34.97	35.21	N	5271
March	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	34.5	50.0	SE	5614	30.43	53.45	N	5984	33.5	45.3	N	7522
April	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	38.5	54.0	N	5012	41.57	53.56	N	6894	46.5	40.2	SE	6553
May	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	58.6	40.0	N	5933	57.3	45.3	S	5623	54.9	45.1	SE	6938
June	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	68.9	38.0	S	6097	67.86	42.26	S	6119	64.0	43.4	N	5792
July	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	73.2	43.0	NW	5464	64.6	68.3	SE	4483	72.0	47.8	N	5479
August	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	70.3	43.0	NW	4701	65.3	63.4	N	4237	.....	.....	.....	.....
September	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	56.7	46.0	SE	5307	57.9	64.4	N	4407	.....	.....	.....	.....
October	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	49.9	50.0	SE	5152	51.3	48.0	N	4583	.....	.....	.....	.....
November	.....	....	.....	.....	.....	.....	.....	.....	37.4	42.6	N	.....	37.9	45.5	SE	5137	37.1	55.9	SE	4440	.....	.....	.....	.....
December	.....	....	.....	.....	.....	.....	.....	.....	42.7	42.7	N	4030	28.1	54.9	N	4428	35.4	44.0	N	5679	.....	.....	.....	.....

DAVENPORT, IOWA.																								
January	.....	....	.....	.....	23.0	.....	WSW	8412	17.1	.....	NW	6104	23.7	82.6	W & NW	5806	9.4	83.5	W	5501	29.79	75.52	SW	7917
February	.....	....	.....	.....	27.8	.....	NE	6884	23.9	.....	NW	6511	25.9	83.0	W	5429	10.9	86.0	W	4805	29.93	70.52	NW	7117
March	.....	....	.....	.....	33.3	.....	NW	6630	36.7	.....	NW	9541	34.7	74.5	NW	8469	30.4	78.8	W	6706	32.17	73.61	NW	8485
April	.....	....	.....	.....	50.9	.....	SW	8125	46.9	.....	SW	6645	41.6	64.8	NE	7752	46.3	60.5	W	7385	51.16	59.05	SW	8917
May	.....	....	.....	.....	61.5	.....	NW	7020	59.6	.....	NE	5922	64.5	58.2	SW	7873	60.9	61.9	E	6536	62.44	63.03	SW	6305
June	.....	....	.....	.....	73.2	.....	SW	.....	77.9	.....	SW	4386	73.2	68.3	SW	6126	68.6	71.4	NW	5514	69.43	70.91	SW	6320
July	.....	....	.....	.....	76.3	.....	NW	4680	75.6	63.0	SW	4711	78.0	63.9	SW	5841	74.0	73.3	E	3770	75.89	69.61	SW	4804
August	.....	....	.....	.....	74.6	.....	SW	4860	78.0	57.0	SW	4426	74.4	67.5	E	5844	69.89	69.01	S	4518	74.94	68.43	SE	4611
September	61.4	....	SSE	5050	64.6	.....	SW	6690	62.3	62.1	SW	6314	65.5	74.0	SW	5147	61.7	70.47	SW	5917	.....	.....	.....	.....
October	54.4	....	SW	6960	52.1	.....	NW	4229	48.3	61.5	NW	5906	52.5	70.8	NW	5654	48.85	62.21	SW	6831	.....	.....	.....	.....
November	33.6	....	ENE	6445	32.9	.....	W	6453	34.6	72.6	NW	6332	36.4	73.8	NW	6659	33.51	67.60	NW	6228	.....	.....	.....	.....
December	20.5	....	WSW	6159	18.7	.....	NW	6010	29.7	82.0	NW	5719	27.9	81.8	W	5654	34.54	75.62	NW	7172	.....	.....	.....	.....
DENVER, COLO.																								
January	.....	....	.....	.....	23.8	.....	S	3696	30.0	.....	NW	4720	31.5	51.5	S	4576	16.79	56.3	N	4131	28.3	40.5	SW	3389
February	.....	....	.....	.....	33.7	.....	S	4600	30.3	.....	N	3558	24.7	63.9	S	2864	32.27	46.6	NE	4146	37.7	38.77	S	4519
March	.....	....	.....	.....	36.32	.....	S	5097	44.0	.....	S	5318	36.4	59.6	NE	4238	33.44	48.4	SSW	6150	34.42	52.69	N	5825
April	.....	....	.....	.....	46.16	.....	N	6276	39.88	.....	N	4761	43.1	54.4	S	4209	44.53	46.8	N	5135	49.34	38.36	S	5071
May	.....	....	.....	.....	57.7	.....	N	3879	53.31	.....	NE	3744	61.9	41.6	S	6159	60.23	38.42	S	5038	57.06	42.07	N	5193
June	.....	....	.....	.....	67.28	.....	S	3815	68.93	.....	S	4193	70.0	41.1	S	5022	70.37	28.0	S	4656	65.85	36.63	S	4382
July	.....	....	.....	.....	69.28	.....	S	3313	71.46	45.0	S	4213	76.1	42.2	S	4932	68.07	55.67	S	4160	76.40	38.63	S	4251
August	.....	....	.....	.....	69.79	.....	S	3246	70.85	49.0	S	3793	73.0	44.3	S	4349	68.97	46.67	S	3887	70.08	42.30	S	4132
September	.....	....	.....	.....	60.05	.....	S	3034	59.79	45.0	S	3294	59.0	43.7	S	4144	61.7	51.3	S	3782	.....	.....	.....	.....
October	.....	....	.....	.....	50.03	.....	S	2962	45.21	51.0	S	3855	52.9	54.5	NE	3889	54.14	33.45	S	3737	.....	.....	.....	.....
November	.....	....	.....	.....	32.51	.....	S	3586	40.6	43.0	S	4331	42.2	42.7	S	5371	37.3	59.8	S	3104	.....	.....	.....	.....
December	29.12	....	S.	5193	27.60	.....	S	2693	22.4	59.0	S	3032	29.7	56.5	S	3732	37.8	43.8	S	4283	.....	.....	.....	.....
DODGE CITY.																								
January	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13.2	63.8	N	5126	35.3	55.7	S	7714
February	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	29.8	72.3	NW	4098	41.5	48.1	W	9236
March	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	38.1	59.8	N	8212	34.7	73.2	N	11571
April	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	47.9	63.9	N	9118	56.6	59.3	N	10923
May	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	65.4	62.7	N	8201	64.5	58.9	E	12010
June	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	75.4	58.5	S	8269	71.2	51.6	SE	11333
July	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	75.5	67.1	NE	6766	79.6	62.1	SE	11311
August	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	74.6	66.6	S	6021	77.2	64.1	S	11196
September	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	68.7	62.7	S	6462	.....	.....	.....	.....
October	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	60.7	55.3	NW	5057	56.6	52.9	SW	6491	.....	.....	.....	.....
November	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	38.4	60.4	NE	3110	39.9	53.0	N	8627	.....	.....	.....	.....
December	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	34.2	67.4	S	3188	40.7	58.4	W	7565	.....	.....	.....	.....
FORT GIBSON.																								
January	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	39.5	71.1	E	7068	27.7	68.7	N	4855	45.4	65.3	SE	6444
February	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	41.3	69.3	E	5564	38.7	62.2	S	6591	47.6	57.8	SE	7354
March	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	52.2	65.7	E	7109	47.7	57.3	SE	8902	44.4	62.8	SE	9540
April	.....	....	.....	.....	.....	.....	.....	.....	56.2	.....	SE	8670	53.0	62.2	N	8361	56.7	56.8	NW	7486	63.4	53.7	SE	7356

Meteorological data afforded for this report by Bvt. Brig. Gen. A. J. Myer, U. S. A., Chief Signal-Officer—Continued.

Station and month.	1871.				1872.				1873.				1874.				1875.				1876.			
	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.
FORT GIBSON-Cont'd.																								
May	.....	.....	.....	.....	.....	.....	.....	.....	67.6	.....	E	6312	70.3	63.8	SE	6718	67.6	68.1	SE	6305	69.6	65.8	SE	6286
June	.....	.....	.....	.....	.....	.....	.....	.....	70.6	.....	SE	4248	78.6	67.9	SE	5471	77.9	68.0	S	6162	73.6	69.9	W	5861
July	.....	.....	.....	.....	.....	.....	.....	.....	80.7	67.0	SE	5138	83.1	61.2	SE	4557	80.0	75.0	S	4385	81.0	72.0	E	4057
August	.....	.....	.....	.....	.....	.....	.....	.....	78.8	61.9	E	3358	86.1	48.4	E	5630	74.6	75.7	SE	3763	81.4	67.6	SE	4460
September	.....	.....	.....	.....	.....	.....	.....	.....	70.2	69.6	SE	5390	71.5	67.9	SE	5265	.....	.....	.....	.....	.....	.....	.....	.....
October	.....	.....	.....	.....	.....	.....	.....	.....	56.9	61.9	E	5410	60.9	65.5	SE	4299	57.7	61.5	SE	5258	.....	.....	.....	.....
November	.....	.....	.....	.....	.....	.....	.....	.....	49.8	58.3	NW & E	11335	50.7	68.7	SE	6685	49.4	64.0	N	5948	.....	.....	.....	.....
December	.....	.....	.....	.....	.....	.....	.....	.....	40.6	75.7	E	6139	43.4	73.0	SE	5659	48.4	61.2	S	6325	.....	.....	.....	.....
FORT SULLY, DAK.																								
January	.....	.....	.....	.....	.....	.....	.....	.....	9.6	.....	NW	6160	16.1	61.6	NW	6758	0.1	61.9	NW	6948	18.7	64.67	NW	7128
February	.....	.....	.....	.....	.....	.....	.....	.....	14.7	.....	E	6506	20.3	63.9	SE	5032	4.2	65.3	NW	6818	14.4	76.0	NW	7356
March	.....	.....	.....	.....	.....	.....	.....	.....	32.4	.....	NW	9310	27.7	59.1	NW	8603	22.3	73.4	SE	9078	15.9	78.3	N	9365
April	.....	.....	.....	.....	.....	.....	.....	.....	41.5	.....	NW	10500	43.9	41.5	NW	8081	39.2	66.1	N	9265	.....	.....	.....	.....
May	.....	.....	.....	.....	58.3	.....	NW	8110	54.5	.....	E	9200	63.2	51.3	SE	9152	60.1	59.7	NW	7638	61.7	53.2	SE	9761
June	.....	.....	.....	.....	70.3	.....	SE	8250	74.2	.....	SE	6900	70.2	63.2	SE	7652	66.0	59.7	SE	9312	68.1	52.0	NW	9332
July	.....	.....	.....	.....	73.5	.....	SE	7425	74.3	49.0	SE	9010	79.2	40.7	SE	8674	73.9	54.7	SE	6189	75.6	58.6	SE	10173
August	.....	.....	.....	.....	72.2	.....	SE	8720	75.5	51.6	ESE	9346	76.1	49.1	SE	8830	71.4	51.2	N	7887	73.1	60.7	SE	8476
September	.....	.....	.....	.....	62.4	.....	NW	8810	57.3	46.8	NW	7896	65.2	39.7	SE	7152	61.3	54.93	N	6753	.....	.....	.....	.....
October	.....	.....	.....	.....	52.3	.....	NW	6990	42.1	53.2	NW	8546	50.9	49.4	SE	7290	48.9	53.22	S	7937	.....	.....	.....	.....
November	.....	.....	.....	.....	24.5	.....	NW	8160	35.1	57.2	NW	6970	26.2	67.6	NW	6438	24.4	63.33	NW	7968	.....	.....	.....	.....
December	.....	.....	.....	.....	11.5	.....	E	6990	14.9	62.9	NW	5197	26.9	62.8	NW	6579	27.0	73.62	NW	6605	.....	.....	.....	.....
KEOKUK, IOWA.																								
January	.....	.....	.....	.....	25.8	.....	W	6593	17.6	.....	W	5464	27.8	79.7	NW	6610	16.7	76.3	NW	6337	34.1	73.2	NW	7922
February	.....	.....	.....	.....	30.4	.....	SE	4827	26.1	.....	NW	5018	29.4	79.7	N	5249	18.1	71.6	NW	5955	35.0	67.6	NW	7670
March	.....	.....	.....	.....	35.0	.....	NW	6230	38.7	.....	NW	7676	38.3	70.5	N	7674	34.1	68.9	SE	7452	34.9	72.8	NW	8016

April	.....	....	.....	.....	53.9	.....	NW	6971	48.5	.....	NW	7181	44.6	63.0	NNE	7681	49.5	60.3	W	7341	53.0	59.4	SE	8827
May	.....	....	.....	.....	64.5	.....	W	5525	61.5	.....	E	7026	67.2	58.3	S	6608	62.9	62.5	SE	6940	63.9	62.5	S	6852
June	.....	....	.....	.....	75.2	.....	S	4427	77.9	.....	SE	4338	76.7	69.3	SW	5145	71.4	72.2	SE	5545	70.1	72.4	NW	6204
July	.....	....	.....	.....	78.6	.....	NW	3716	76.3	68.4	SE	4583	80.5	60.9	SW	4114	76.3	75.8	SW	3546	76.5	74.0	E	5059
August	.....	....	.....	.....	77.3	.....	S	4117	78.7	59.2	SW	3596	76.8	67.9	E	4979	71.6	70.5	S	4909	76.2	71.5	S	4842
September	63.4	....	NE	4333	68.2	.....	S	5541	63.9	65.8	NW	5576	67.1	76.0	S	4651	64.3	68.6	S	4819	.....	.....	.....	.....
October	57.3	....	S	5477	55.5	.....	SW	5064	49.8	66.9	NW	5424	55.7	68.2	NW	5215	51.1	62.1	SW	5583	.....	.....	.....	.....
November	30.5	....	NW	5684	34.6	.....	W	5157	38.9	66.3	NW	6753	40.2	67.7	S	6933	35.3	67.0	N	5694	.....	.....	.....	.....
December	25.8	....	NW	6274	20.5	.....	NW	4276	32.0	79.6	W	6424	31.6	77.4	NW	5931	36.5	77.6	NW	6240	.....	.....	.....	.....
LEAVENWORTH, KANS.																								
January	.....	....	.....	.....	25.0	.....	NW	5533	19.0	.....	N	5147	28.4	67.0	S	2960	16.7	69.5	NW	4812	35.4	71.0	S	6534
February	.....	....	.....	.....	30.9	.....	NW	4301	30.0	.....	NW	5614	28.8	72.3	S	4243	22.3	74.5	NW	4626	38.3	60.5	S	7126
March	.....	....	.....	.....	37.0	.....	NW	6068	42.1	.....	S	8047	40.0	70.4	N	5924	37.6	60.2	NW	5731	35.16	72.6	NW	7862
April	.....	....	.....	.....	56.2	.....	SW	6595	48.6	.....	N	7804	49.0	62.1	N	6280	49.8	55.2	NW	5640	55.24	60.9	S	7025
May	.....	....	.....	.....	65.6	.....	SW	5174	63.0	.....	S	5442	67.3	60.0	S	5632	65.8	57.6	S	5644	65.5	64.9	S	6475
June	.....	....	.....	.....	77.2	.....	SW	5411	75.5	.....	S	4468	77.4	69.5	S	4872	76.7	58.8	S	5778	71.2	66.0	S	.....
July	.....	....	.....	.....	78.4	.....	SE	3051	77.5	61.0	S	4902	82.8	59.5	S	4698	77.6	73.7	S	3401	78.9	69.7	S	3440
August	.....	....	.....	.....	78.4	.....	SE	2839	79.2	54.6	S	3869	81.3	56.0	S	4522	73.1	69.5	S	4223	78.2	69.8	S	3226
September	66.7	....	E	3662	67.7	.....	SW	4423	65.4	58.0	S	5672	66.8	70.0	S	4286	66.6	66.8	S	4298	.....	.....	.....	.....
October	56.9	....	W	4787	56.4	.....	SE	3537	56.9	50.7	S	6040	57.0	67.0	S	4271	53.6	59.8	S	5245	.....	.....	.....	.....
November	38.0	....	NW	4896	35.0	.....	NW	6569	41.8	54.3	N	6095	40.0	65.8	S	5758	37.3	62.2	N	5228	.....	.....	.....	.....
December	24.2	....	NW	5253	21.0	.....	N	5199	31.9	68.0	N	.....	32.7	70.8	S	4442	39.9	68.0	S	5522	.....	.....	.....	.....
NORTH PLATTE, NEBR.																								
January	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7.41	70.01	NW	5493	23.6	65.0	SW	4110
February	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	21.31	72.68	NE	5000	32.4	54.8	NW	5466
March	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	33.19	61.36	NW	8254	27.9	68.2	SE	6607
April	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	42.17	66.16	NW	7604	50.3	53.5	SE	7563
May	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	61.32	.....	SE	7601	59.6	57.5	SE	7978
June	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	69.92	56.69	SE	6954	67.9	42.9	N	7333
July	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	72.5	66.4	NE	3518	76.3	53.9	SE	12243
August	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	71.7	59.2	SE	4797	72.8	58.9	SE	11239
September	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	62.5	60.0	SE	4643	.....	.....	.....	.....
October	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	52.4	64.5	NW	5683	53.4	55.4	NW	4991	.....	.....	.....	.....
November	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	35.7	58.9	SW	6230	31.5	67.8	SE	4479	.....	.....	.....	.....
December	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	28.3	70.1	NW	5044	34.0	64.3	NW	4294	.....	.....	.....	.....
OMAHA, NEBR.																								
January	.....	....	.....	.....	19.0	.....	NW	6000	16.9	.....	N	6424	22.3	78.1	S	7447	16.1	75.9	NW	7438	26.8	73.7	S	7317
February	.....	....	.....	.....	27.5	.....	NW	4045	26.9	.....	NW	5815	23.4	78.7	NNW	4782	13.8	85.5	N	6904	30.1	66.1	NW	8359
March	.....	....	.....	.....	31.0	.....	NW	5160	38.2	.....	S	8895	33.8	70.7	N	6746	30.5	72.6	NW	9353	29.3	80.0	NW	7683
April	.....	....	.....	.....	51.0	.....	SE	5820	44.2	.....	NW	8586	45.1	55.5	N	6838	45.4	60.0	N	8290	51.3	62.7	S	7853
May	.....	....	.....	.....	61.0	.....	SSE	4850	59.0	.....	N	6556	66.6	54.8	S	7801	63.2	58.4	SE	7134	63.6	61.6	S	7935
June	.....	....	.....	.....	72.7	.....	SSE	4645	74.4	.....	S	5623	73.2	68.8	S	7074	71.1	70.9	S	6229	68.6	63.7	N	7156
July	.....	....	.....	.....	77.0	.....	SE	3958	75.7	74.2	S	6074	80.0	60.9	SSW	6084	74.4	75.3	SE	4246	75.1	74.1	S	5605
August	.....	....	.....	.....	75.6	.....	SSE	4521	77.1	72.7	S	4687	77.3	63.8	S	5137	70.2	74.5	S	6350	75.4	73.7	S	5516
September	.....	....	SE	4250	62.8	.....	SE	5244	60.6	64.2	S	6209	63.0	71.8	S	5696	62.9	74.6	S	5958	.....	.....	.....	.....
October	52.4	....	SE	5540	53.0	.....	S	4282	48.5	62.4	NW	7671	54.0	63.8	N	6435	49.6	66.5	S	7611	.....	.....	.....	.....
November	31.0	....	NW	6521	30.6	.....	NW	6798	38.5	58.0	NW	8112	36.0	64.8	N	7994	32.6	70.4	N	7313	.....	.....	.....	.....
December	16.0	....	NW	5651	19.0	.....	N	5874	25.2	80.8	NW	6199	28.4	74.6	S	6905	33.5	69.8	NW	6737	.....	.....	.....	.....

Meteorological data afforded for this report by Bvt. Brig. Gen. A. J. Myer, U. S. A., Chief Signal-Officer—Continued.

Station and month.	1871.				1872.				1873.				1874.				1875.				1876.			
	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.
SAINT PAUL, MINN.																								
January	15.9	....	.....	.....	15.1	.....	NW	3650	6.7	.....	NW	5917	13.8	74.8	SE	6747	−2.35	75.04	SW	5151	16.59	74.02	NW	5880
February	22.3	....	.....	.....	20.3	.....	SE	5250	14.3	.....	SW	5438	14.4	73.0	SE	4489	−1.76	70.92	NW	5589	17.38	73.35	NW	6258
March	32.0	....	.....	.....	21.9	.....	NW	4930	26.7	.....	NW	7100	23.7	70.4	NW	7585	22.00	75.93	SE	6968	24.26	72.78	NW	6469
April	54.4	....	.....	.....	45.1	.....	SE	6920	41.9	.....	NNW	5192	37.5	55.6	N	6840	39.73	61.01	NW	6879	43.93	56.58	NW	7286
May	64.0	....	.....	.....	55.2	.....	W	7120	55.1	.....	N	5678	62.2	52.6	N	7899	58.81	53.97	SE	6724	59.16	58.99	SE	6800
June	67.4	....	.....	.....	67.9	.....	SE	5980	73.0	.....	SE	5935	68.7	71.2	SE	6889	63.59	67.58	SE	6735	66.27	65.09	NW	6604
July	71.3	....	.....	.....	71.2	.....	S	4610	71.0	68.7	SE	4944	74.7	66.5	SE	6004	73.81	63.93	NW	4534	.....	.....	SE	5141
August	68.5	....	.....	.....	69.2	.....	S	5480	70.7	72.9	SE	5125	70.5	73.4	SE	5833	66.6	70.98	SE	5632	69.9	71.8	SE	5992
September	61.6	....	SE	4575	57.6	.....	.....	6244	54.1	83.3	NW	6719	60.9	72.8	SE	6397	57.24	74.59	SE	4864	.....	.....	.....	.....
October	47.3	....	NW	4845	47.2	.....	SE	5984	41.3	69.8	NW	7097	49.4	68.9	NW	6551	42.79	67.89	NW	5750	.....	.....	.....	.....
November	27.8	....	N	4450	23.8	.....	NW	5729	25.6	76.5	NW	6142	28.7	75.6	SE	7339	25.19	68.48	SE	6113	.....	.....	.....	.....
December	9.9	....	SW	4435	.....	.....	.....	.....	18.6	78.3	SW	5903	18.8	75.6	NW	6270	25.49	78.09	SE	6178	.....	.....	.....	.....
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January	.....	....	.....	.....	27.0	.....	N	4104	29.0	.....	N	5181	31.0	60.5	N	5717	28.1	51.1	N	4724	29.0	46.8	NE	4878
February	.....	....	.....	.....	34.0	.....	N	4664	32.0	.....	SW	4773	27.8	62.0	NW	5083	31.4	48.4	N	5796	32.8	38.7	NW	5796.5
March	.....	....	.....	.....	38.8	.....	N	4640	44.0	.....	SW	5335	36.2	48.1	SW	5621	34.4	36.3	SW	7364	36.5	45.1	SW	7464.4
April	.....	....	.....	.....	45.8	.....	SW	6065	44.0	.....	N	5816	42.1	35.8	E	5945	47.4	24.1	SW	6820	50.2	40.9	SW	6122.8
May	.....	....	.....	.....	58.1	.....	N	4730	56.0	.....	SW	5449	59.8	23.1	E	7391	59.2	25.3	SW	7405	55.9	42.1	SW	6818.5
June	.....	....	.....	.....	66.9	.....	SW	3855	65.6	.....	N	5050	69.3	19.5	SW	.....	67.9	19.8	SW	6933	66.0	46.7	SW	6569.8
July	.....	....	.....	.....	67.6	.....	NE	3607	71.0	.....	SE	5796	71.1	37.9	E	5286	65.2	54.9	SW	5437	69.2	64.6	E	5281
August	.....	....	.....	.....	67.0	.....	S	3430	66.0	55.0	SW	5013	69.9	39.7	SW	5731	66.5	46.8	SW	5688	65.2	67.9	SW	4909
September	.....	....	.....	.....	60.0	.....	SE	3231	61.0	41.0	SW	4562	60.5	38.7	E	5163	58.7	56.1	SW	4879	.....	.....	.....	.....
October	.....	....	.....	.....	49.0	.....	SE	3131	51.0	35.1	E	4799	52.3	42.3	SW	5187	53.5	23.7	E	5503	.....	.....	.....	.....
November	.....	....	.....	.....	33.0	.....	N	4040	41.1	32.0	N	3594	38.7	47.4	N	5525	38.7	54.1	SW	4587	.....	.....	.....	.....
December	34.3	....	N	2551	32.6	.....	N	4116	25.8	54.0	N	5675	29.2	44.5	N	4611	32.6	47.7	N	5630	.....	.....	.....	.....

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January	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15.6	68.0	NW	8679	0.6	68.9	NW	6896	18.87	62.8	NW	6652
February	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18.8	69.0	NW	5811	2.5	72.8	NW	6098	20.77	61.48	NW	7601
March	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	30.6	71.0	NW	8071	23.7	74.5	NW	9366	20.39	75.5	NW	8142
April	.....	.....	.....	.....	.....	.....	.....	.....	40.09	.....	N	12823	44.4	50.0	NE	8143	40.4	66.0	NW	7992	46.71	61.93	NW	8532
May	.....	.....	.....	.....	.....	.....	.....	.....	54.19	.....	NE	11465	62.1	53.0	S	9654	61.2	58.8	NW	7253	61.58	61.71	SE	8653
June	.....	.....	.....	.....	.....	.....	.....	.....	72.56	.....	S	8956	70.7	67.0	SE	5719	66.1	72.2	SE	6059	65.66	61.22	NW	6999
July	.....	.....	.....	.....	.....	.....	.....	.....	74.68	75.8	S	6706	78.2	59.0	SW	6072	71.8	74.3	SE	3252	73.29	72.47	S	5997
August	.....	.....	.....	.....	.....	.....	.....	.....	77.08	74.6	E	6212	74.2	69.0	SE	5980	68.3	72.0	SE	5088	72.05	70.87	SE	6254
September	.....	.....	.....	.....	.....	.....	.....	.....	60.4	72.3	NW	6222	61.7	68.0	NW	5684	60.57	75.58	NW	5490	.....	.....	.....	.....
October	.....	.....	.....	.....	.....	.....	.....	.....	46.1	75.9	NW	.....	49.4	63.0	NW	6891	47.18	63.4	NW	6460	.....	.....	.....	.....
November	.....	.....	.....	.....	.....	.....	.....	.....	35.9	59.0	NW	7916	30.4	67.0	NW	6982	25.89	63.8	NW	6715	.....	.....	.....	.....
December	.....	.....	.....	.....	.....	.....	.....	.....	18.1	70.0	NW	6785	23.0	67.8	NW	6382	27.35	63.31	NW	5260	.....	.....	.....	.....

THE EASTERN RED-LEGGED LOCUST, *Acrydium femur-rubrum* De Geer; *Caloptenus femur-rubrum* White (Plate LXII, Fig. 5*b*).—A medium-sized grasshopper, the male differing chiefly from the male *spretus* in the end of the abdomen not being notched, but rounded and much blunter; ranging from Labrador and Canada to the Pacific Coast, including the border States and the Mississippi Valley, not extending south of latitude 35°, occasionally in dry seasons becoming very destructive and gathering in local swarms, but not commonly migrating far from its breeding-place.

All that has been published in regard to the breeding-habits of the eastern red-legged locust is the following passage in Harris's Treatise on the Injurious Insects of Massachusetts: "It comes to maturity with us by the latter part of July; some broods, however, a little earlier, and others later. It is most plentiful and destructive during the months of August and September, and does not disappear till some time in October." Of the larva and its habits we have nothing on record, but it is probable that it hatches late in May and early in June, and as the latitude varies becomes winged in seven or eight weeks or sooner. I have observed the locusts copulating and laying their eggs at Amherst, Mass., during the middle and last of September, after the first frosts, and they continue doing so into October. While they oviposit in the soil of upland meadows and hay-fields, they are more commonly seen in hard gravelly paths in company with *Œdipoda*, *Sordida*, and *Carolina*, and other grasshoppers. Having put a few into a glass jar partly filled with dirt I was able to observe the process.

I placed several *C. femur-rubrum* under glass in a vessel filled with gravelly soil. The insect in boring into the ground brings the end of its abdomen forward so as to be nearly perpendicular to the rest of the body. The end of the abdomen, armed with its stout spines, is then slowly thrust down, not being retracted during the operation unless the insect is disturbed. The hole thus made is not over an inch deep and about one-fifth of an inch in diameter. Plate LXIV, Fig. 4, represents this species after the hole has been made. The size and form of the egg-sac and eggs is shown on the right of the figure. It is 15 millimeters long and 5 millimeters in diameter, the eggs being shown through the thin wall of the sac, which in those I have seen is thinner and lighter than in *C. spretus*, the amount of the spongy substance secreted by the insect being perhaps less. I have ventured to represent a mass of this glutinous matter coming from the body of the female. It is possible that the drawing (made by Mr. Emerton, from a sketch made by myself from life) is incorrect in this particular. The spongy glutinous substance (probably a modified silky secretion) may be deposited in part at first and the eggs arranged in it, passing out of the end of the oviduct singly.* The cockroach ejects her eggs all at once and contained in a sac. In the egg-sacs which I observed the eggs were not arranged so regularly as in those of the Rocky Mountain locust. During the process the abdomen is nearly half longer than usual and greatly distended. The eggs are curved cylindrical, of the same form as in *C. spretus*, but considerably smaller, being 4 millimeters in length. The chorian is pitted in the same manner, and there is a similar constriction at the posterior end.

In *Œdipoda sordida* the egg-mass is 14 millimeters long and 5 millimeters in diameter. The eggs are of the usual size and 5 millimeters in length.

From Mr. S. J. Smith's description (Proceedings of the Portland Society of Natural History) of the mode of oviposition in *Choëaltis con-*

* Mr. W. S. Dallas thinks that the glutinous mass is first produced by the insect, and the eggs afterward laid in it. (Zoölogical Record for 1867.) Further observations are necessary to determine this point; they can (p. 460) easily be made, however.

spersa, it would appear that the eggs are probably laid singly, and that the glutinous substance which afterward becomes spongy and hard is exuded before and during the extension of the eggs, which are each arranged with more or less care so as to pack most closely, forming a cylindrical egg-mass. By means of the anal appendages the female excavates in soft, rotten wood a smooth round hole about an eighth of an inch in diameter. The eggs are placed in two rows, one on each side, and inclined so that, beginning at the end of the hole, each egg overlies the next in the same row by about half its length. The aperture is closed by a little disk of a hard, gummy substance. While boring their holes a frothy fluid is emitted from some part of the abdomen; but whether it serves to soften the wood or to lubricate the appendages and the sides of the hole, I did not determine.

When the hole is made and while the eggs are being deposited, the female sits with her body inclined at a low angle, the ends of the folded wings resting on the ground, and the fore and middle pair of feet in their usual position, the body being mainly supported by the hind legs, which are placed as drawn in the figure, resting firmly on the ground, not elevated as in Riley's figure of *C. spretus*. A female in confinement, September 24, at Amherst, Mass., was observed at 2 p. m. with its abdomen deeply inserted in the soil; at 3.10 p. m. it began to withdraw with much deliberation its abdomen; it stopped during the process of extraction, having withdrawn its abdomen about a quarter of an inch out of the hole; at 3.20 p. m. it entirely withdrew its abdomen. It had laid twenty eggs, naked, in a mass, not having deposited around them any appreciable amount of glutinous matter, though the dirt formed a partial covering for it. This female lived several days after, when I killed it to examine the ovaries, in which were fifteen ovarian eggs from one-third to one-half the size of the ripe eggs.

Another *C. femur-rubrum* was observed in the act of laying for a hour and a half, but the beginning and end of the process was not observed. It seems probable from these observations that the process requires at least more than two hours, and this being the case it is possible that the eggs are laid singly, otherwise the mass might be deposited at once, in a few minutes. During the process the females are not easily disturbed.

Several *Œdipoda sordida* and *carolina* were observed laying in the gravelly walk which I frequented every day for a week or fortnight. An *Œ. sordida* in confinement was observed beginning to bore its hole, pushing the dirt backward and forward with its spines on the abdomen. The duration of the process of copulation not observed.

Dr. Harris has collected, in passages often quoted, the accounts of their ravages in Northern New England during the last century. They appeared most frequently in Maine and were alarmingly abundant in the summers of 1743, 1749, 1754, 1756; in Vermont, in 1797, 1798. They were not afterward noticed by local historians until 1821 or 1822. I condense the following account, the best we can get here, of their migrations, by Dr. N. T. True, communicated to Mr. S. H. Scudder and published in full in the "Final Report of the United States Geological Survey of Nebraska," &c., by F. V. Hayden, 1872. The year 1821 or 1822 was an unusually dry season during the summer months. They devoured the clover and herds-grass, and even nibbled the rake and pitchfork handles made of white ash. "As soon as the hay was cut, and they had eaten every living thing from the ground, they removed to the adjacent crops of grain, completely stripping the leaves; climbing the naked stalks, they would eat off the stems of wheat and rye just below the

head, and leave them to drop to the ground. * * * * Their next attack was upon the Indian corn and potatoes. They stripped the leaves and ate out the silk from the corn, so that it was rare to harvest a full ear. Among forty or fifty bushels of corn spread out in the dry-room, not an ear could be found not mottled with detached kernels. While these insects were more than usually abundant in the town generally, it was in the field I have described that they appeared in the greatest intensity. After they had stripped everything from the field they began to emigrate in countless numbers. * * * * They crossed the highway and attacked the vegetable-garden. I remember the curious appearance of a large, flourishing bed of red onions, whose tops they first literally ate up, and, not contented with that, devoured the interior of the bulbs, leaving the dry external covering in place. * * * * The leaves were stripped from the apple-trees. They entered the house in swarms, reminding one of the locusts of Egypt, and as we walked they would rise in countless numbers and fly away in clouds. As the nights grew cooler, they collected on the spruce and hemlock stumps and log fences, completely covering them, eating the moss and decomposed surface of the wood, and leaving the surface clean and new. They would perch on the west side of a stump where they could feel the warmth of the sun, and work around to the east side in the morning as the sun reappeared. The foot-paths in the fields were literally covered with their excrements.

"During the latter part of August and the first of September, when the air was still dry, and for several days in succession, a high wind prevailed from the northwest, the locusts frequently rose in the air to an immense height. By looking up at the sky in the middle of a clear day, as nearly as possible in the direction of the sun, one may descry a locust at a great height. These insects could thus be seen in swarms, appearing like so many thistle-blows as they expanded their wings and were borne along toward the sea before the wind; myriads of them were drowned in Casco Bay; and I remember hearing that they frequently dropped on the decks of coasting-vessels. Cart-loads of dead bodies remained in the fields, forming in spots a tolerable coating of manure.

"It was an object of curiosity to me, then a boy, to catch some of the largest locusts, and turn up their wings to find the little red parasite which covered their bodies. This might have done something toward hastening their destruction, although it did not prevent the ravages on the crops.

"During the years necessary to clear up the forests on the sandy lands in the vicinity, it was no uncommon thing to have the crops seriously injured by these locusts, but never, to my knowledge, to the extent described above.

"In response to my special inquiries concerning the flight of these insects, my correspondent replied as follows: 'I do not remember ever to have witnessed the flight of these grasshoppers to any extent, except during the year mentioned and the preceding one. Nor do I ever recollect a time when the wind blew so steadily for days in succession from the northwest, generally rising soon after midday and going down with the sun. I have no meteorological record, but speak from memory.'

"The town of Pownal was principally settled after the opening of the present century. As the lands were cleared, the Canada thistle and other species sprang up in great quantities; when they ripened, the wind spoken of as occurring at that time carried off immense numbers of the thistle-blows to the ocean. I was wont to spend hours in my boyhood lying on the ground and directing my eyes as near as I could

to the sun, to watch the thistle-blows as they passed across or near its disk. I think I could have seen them in this situation several hundred feet high. I injured my eyes permanently by indulging in this amusement. Whether the grasshoppers ever rose to so great a height I do not know, but I think that they generally flew at a lower level. Altogether they would rise in clouds as one approached them; it was only an occasional one that would rise higher, and fly off before the wind, and then only when the wind was blowing freshly. They did not fly with their heads directly before the wind, but seemed to rise in the air, set their wings in motion, and suffer themselves to be borne along by the current. They generally, perhaps always, rose in the afternoon, when the sun was hot and the wind blowing freshly."—(From accounts furnished by Dr. N. T. True, Bethel, Me., February 28 and March 10, 1868.)

In Ohio and Pennsylvania, according to Mr. A. S. Taylor, the grasshoppers made their appearance in vast numbers. In 1859 Mr. Schenck, of Franklin, Warren County, Ohio, wrote to the Ohio Farmer: "Last year we had millions of them; this year we have hundreds of millions." For five years, he says, they have been increasing on his farm, and he fears that unless some means are discovered for their destruction they will totally ruin his own and his neighbors' clover-fields. The speed of the Central Railroad locomotives is considerably decreased by the immense swarms of grasshoppers between Lancaster and Philadelphia. One engineer stated that his train was forty minutes behind owing to the number of grasshoppers on the track, and that he used twenty buckets of sand, which was thrown on the rail in front of the driving-wheels, to enable him to get along at all, Improbable as this story may appear, its truth is vouched for by the engineer above alluded to. (Hayden's Report on Nebraska, 1872.) In 1868, locusts, principally the red-legged species, appeared, according to Riley, in countless myriads in Ohio, invading the vineyards, "destroying entire rows, defoliating the vines, and sucking out the juices of the berries. In the same year I saw them in countless millions in many parts of Illinois and Missouri. They actually stripped many corn-fields in these States, and had not the crops been unusually abundant, would have caused some suffering. They were very destructive to flower and vegetable gardens. In 1869 they were, if anything, worse than in 1868. I remember that in the vicinity of Saint Louis, in addition to their ordinary injuries, they stripped the tops of Norway spruce, balsam-fir, and European larch; took the blossoms off Lima beans, severed grape-stems, and ate numerous holes into apples and peaches, thereby causing them to rot. They were indeed abundant all over Illinois, Missouri, Iowa, and even Kentucky, but attracted no attention east."—(Riley's Seventh Report.)

In the year 1871, the summer of which was dry, while I was in Orono, Me., in July reports came from Aroostook County that the hay-crop was being devoured by the locusts; and in August the evil became still worse, and they attacked the other crops, and became more or less destructive all over the State. They also, as quoted by Riley from the Monthly Report of the Agricultural Department, abounded in Plymouth County, Massachusetts, and in Vermont, as well as in Wayne County, Pennsylvania. In 1872, they were very abundant in New Hampshire, and in 1874 they were destructive in Missouri. In 1875 they were very abundant in the salt-marshes of Essex, Mass., as I was informed by a summer-resident there.

In 1876, in the Monthly Report of the Department of Agriculture for July, it was noted as injurious "in Sullivan, N. H. In Franklin, Va.,

it was very destructive on tobacco; as also in Person, N. C.; in Cherokee, Ala.; in Robertson and Montgomery, Tenn." In the Report for November and December, it is stated that "Owsley, Ky., reports a great destruction of early-sown wheat by a grasshopper, which is most probably the *Caloptenus femur-rubrum*."

Besides the localities given by Professor Thomas, I have received a male from California, near San Francisco, through Mr. Henry Edwards. The specimen was submitted to Mr. Scudder, who identified it. Mr. Walker* gives the following localities for it: "Arctic America; presented by Sir John Richardson. Arctic America; presented by Dr. Rae. Vancouver's Island-Nova Scotia; from Lieutenant Redman's collection. West coast of America; presented by Captain Kellett and Lieutenant Wood," etc.

On the map showing the distribution of this species, I have represented it as occurring over the whole of Labrador, for if it is found in Arctic America, it must be found there. During a residence of six weeks in the summer of 1860 at the mouth of Esquimaux River, Straits of Belle Isle, I never met with any *Orthoptera*. I heard, however, of grasshoppers about 20 miles in the interior, but they were very few in number. In the summer of 1864, while entomologizing at different points as far north as Hopedale, I never saw any.

We still need information regarding the southern and southeastern limits. I have also indicated on the map the approximative limits of the area where it has been found to be destructive at certain seasons.

Description.—Grizzled with dirty olive and brown; a black spot extending from the eyes along the sides of the thorax; an oblique yellow line on each side of the body beneath the wings; a row of dusky brown spots along the middle of the wing-covers, and the hindmost shanks and feet blood-red, with black spines. The wings are transparent, with a very pale greenish-yellow tint next to the body, and are netted with brown lines. The hindmost thighs have two large spots on the upper side, and the extremity black; but are red below and yellow on the inside. The appendages at the tip of the body in the male are of a long triangular form. Length, from 0.75 to 1 inch; expansion of wings, 1.25 to 1.75 inches.—(Harris.)

As this species, which is so common, varies considerably, I have concluded to give Dr. Harris's description without change, adding the following: Vertex but slightly depressed, with a minute angular expansion in front of the eyes; frontal costa usually but slightly sulcate; sides parallel; eyes large and rather prominent. Elytra and wings generally a little longer than the abdomen. The cerci of the male rather broad and flat; apex of last ventral segment is entire and truncate. The yellow stripes on the side extend from the base of the wing to the insertion of the posterior femora. The ground color varies with localities and age, and most of the specimens from one or two sections appear to have unspotted elytra; sometimes a reddish-brown tint prevails; at others a dark olive; at others a dark purplish-brown; yet the markings generally remain the same.—(Thomas, Acrididæ N. A.)

THE DESTRUCTIVE LOCUST OF CALIFORNIA, *Œdipoda pellucida* Scudder. *Œ. atrox* Scudder. (Plate LXIV, Fig. 5.)

"A third species of grasshopper, unnamed as yet, belonging to the genus *Œdipoda*, appears to be the insect which has ravaged the cultivated districts of California and Oregon, and the neighboring States and Territories. It probably ranges over the whole extent of country west of the Rocky Mountains and included within the limits of the United States. Mr. A. S. Taylor, in one of his articles in the California Farmer, subsequently communicated to the Smithsonian Institution and published in their Report for 1858, describes the grasshopper as found near Monterey, and it is doubtless the migratory species which ravaged the State. It is a species of *Œdipoda*, which, from the devas-

* Catalogue of the Specimens of Dermoptera Saltatoria in the Collection of the British Museum. Part iv. London, 1870.

tating nature of its ravages, may be called *Œdipoda atrox*, or the terrible grasshopper. To the best of my knowledge, it is the only species of the genus which has anywhere proved seriously and persistently injurious to crops. Several species of the closely-allied genus *Pachytylus* have ravaged the fields of Eastern Europe and Asia; and it is interesting, in a zoölogical point of view, to find that California, whose insect fauna bears a much more general resemblance to the peculiar types of the Old World than to those characteristic of the opposite border of the New World, should in this case also harbor a devastating grasshopper so much more nearly allied to the destructive species of the Mediterranean than to those found upon the same continent with itself.

Whether the *Œdipoda pellucida* (*atrox*) or *Caloptenus spretus* is the species which has proved at times so destructive on the Pacific coast has been a matter of some uncertainty. Mr. Scudder (Hayden's Report on the Geology of Nebraska, 1872) believes that it is this species, while Mr. Thomas (Monograph of *Acrididæ*) thinks it must be *C. spretus*. As seen in the previous account of *C. spretus* in California by Mr. Henry Edwards (p.), he regards that locust as the destructive species. Concerning the habits of *Œ. pellucida* in California, he writes me the following explicit account: "*Œdipoda* (*Camnula*) *atrox*. This species is very abundant in the spring and early summer, but at present (1876) appears to be somewhat limited in its range as far as California is concerned. It is found only in our foot-hills, and has not, to my knowledge at least, been regarded as a very destructive insect. I never saw it but once in very large swarms, and it then appeared to attach itself more to the pasture-grasses than to any growing crops, although there were plenty of fields of barley, oats, &c., in the neighborhood. It appears in its larval condition in April, and in the winged state in May, passing entirely out of existence by the middle of June. I have taken it sparingly in Nevada and in Vancouver's Island, and have seen some specimens from Santa Rosa Island, but I am pretty sure that it cannot be called a common insect in those localities." Regarding its habits and distribution in the East I quote as follows from Scudder's Distribution of Insects in New Hampshire (Hitchcock's Geology of New Hampshire, vol. 1): "This insect is silent in flight, and is a northern species, swarming in immense numbers among the White Mountains and on the dry summits of the country south of it. The top of Mount Prospect, near Plymouth, was covered with myriads of them in the autumn of 1873. It is found, however, as far south as Connecticut and Southern Illinois, and west to the latter region and Lake Superior." Thomas states that he has found it in Montana.—(Acrididæ of North America, p. 137.)

Concerning this species, Professor Thomas remarks as follows in Hayden's Annual Report on the Geology of Montana for 1871, p. 458: "Those who live in the East and have not seen a specimen of this species, can see it almost, if not exactly, represented in *Œ. pellucida* of Scudder; in fact, Mr. Scudder's description of this species agrees more exactly, if possible, with specimens from California, submitted to me this season, than his description of *atrox*." In his "Synopsis of the Acrididæ of North America," Hayden's Survey, 1873, he again says: "I give this species as distinct from *Œ. pellucida* on the authority of Dr. Scudder, but I consider the two as identical, the only difference that I can see being that the median carina of *atrox* is severed, while that of *pellucida* is continuous. The coloration shows less difference than is often observed between different specimens of the same species from the same locality. In fact, my specimens of *atrox* agree more

exactly with Dr. Scudder's description of *pellucida* than with that of *atrox*, with the exception given."

I am inclined, from the reasons above given, to regard *atrox* as a synonym of *pellucida*, and that its range agrees in the main with that of *Œ. carolina*, which is found on the Pacific coast (Vancouver's Island), according to Walker, and probably Thomas.

Mr. Henry Edwards, of San Francisco, kindly furnishes the following notes:

"This species is very abundant in the spring and early summer, but at present appears to be somewhat limited in its range as far as California is concerned. It is found only in our foothills, and has not, to my knowledge at least, been regarded as a very destructive insect. I never saw it but once in very large swarms, and it then appeared to attach itself more to the pasture grasses than to any growing crops, although there were plenty of fields of barley, oats, &c., in the neighborhood. It appears in its larval condition in April, and in the winged state in May, passing entirely out of existence by the middle of June. I have taken it sparingly in Nevada and in Vancouver Island, and have seen some specimens from Santa Rosa Island, but I am pretty sure that it cannot be called a common insect in those localities."

Description of the adult.—Head uniform, pale brownish-yellow; the raised edge of the vertex dotted with fuscous; a dark fuscous spot behind the eye, broadening posteriorly, but not extending upon the pronotum. Antennæ as long as the head and pronotum together, dull honey-yellow, growing dusky toward the tip. Pronotum dark brownish-yellow, the sides darker anteriorly; median carina extending the whole length of the pronotum, moderately raised, cut once by a transverse line a little in advance of the middle; lateral carinæ prominent, extending across the anterior two-thirds of the pronotum; anterior border of the pronotum smooth, very slightly angulated; posterior border delicately marginate, bent at a very little more than a right angle, the apex rounded; tegmina dull-yellowish on the basal half, with distinct fuscous spots; toward the apex obscurely fuscous, with indistinct fuscous markings; humeral ridge yellowish, and, when the tegmina are in repose, inclosing a brownish fuscous triangular stripe; the spots are scattered mostly in the median field, consisting in the basal two-fifths of the tegmina of small roundish spots, and one larger longitudinal spot in the middle of the basal half; there is a large irregular spot in the middle of the tegmina, and beyond a smaller transverse spot, followed by indistinct markings; wings hyaline, slightly fuliginous at the extreme tip; the veins, especially in the apical half, fuscous; legs uniform brownish fuscous; apical half of spines of hind tibiæ black.

Length of body, 0.9 inch; of tegmina, 0.9 inch; of body and tegmina, 1.125 inches; of pronotum, 0.2 inch; of hind femora, 0.5 inch.

It bears a strong resemblance to *Œdipoda pellucida*, Scudd., common in Northern New England.—(Scudder in Hayden's Geological Report on Nebraska, 1872, p. 250.)

THE AMERICAN LOCUST, *Acrydium americanum* Drury (Plate LXIV, Fig. 6.)

This is one of our largest grasshoppers, being a little over two inches in length. It is occasionally very destructive to vegetation in the Southern States. According to Professor Thomas it occurs in North Carolina, Southern States, Florida, Alabama, Texas (Scudder); Illinois, Tennessee, Mississippi, District of Columbia (Thomas); Virginia, New York (?Drury). I have observed it very abundantly in Virginia, at Danville, in April and early in May. The figure (after Riley) is so good that further description is unnecessary.

In the pupa state this species is occasionally destructive. I have received from Prof. D. S. Jordan specimens which I regard as the pupæ of this species, with the following notes on its habits:

"While seining in Rome, Ga., in the Etowah River, I noticed, about July 25, a fence covered completely with large grasshoppers not fully fledged and extremely brilliant in color. They were very hyaline and of all shades from a clear pea-green to pale clear yellow and a sort of clear reddish amber (scarcely any two the same; all become pale yellow in

spirits) color. We found them so thick that we could collect them by the handful, and in consequence of their abundance and brilliancy (else I should not have noticed them) I secured a couple of quarts. All I have at hand I send by American Express to-day, but will send a hundred more if you wish.

"A negro who was mowing near told us that he had never seen that kind of grasshopper before and that they were destroying the cotton. We found no more in the neighborhood of Rome.

"On a visit to Atlanta a week or so later we heard doleful complaints about a new sort of 'hoppergrass' that was destroying everything, particularly the corn and cotton. This kind was said by the Atlanta papers and farmers generally to have been hitherto unknown in Georgia, and we were shown a lot of live specimens on a cotton-plant in a glass globe in the rooms of the State Agricultural Department at Atlanta. The officials asked us if that was not the terrible Kansas hopper. I knew just enough about those fellows to assure them that it was not.

"Later (August 12), near Lookout Mountain on Chattanooga Creek, we saw several splendid fields of corn utterly devastated by these grasshoppers. The silk was gone and *all* the leaves and the husks peeled down as close as if a sheep had been at them, or a rat. I suppose the corn was not worth cutting at all, not even for fodder. As usual, all the fences were covered. We collected here four hundred or five hundred and put them in a large wire cage of lizards and chameleons for the latter to feed on, but the insects tormented the reptiles so much that we had to throw them away."

This species, when winged, sometimes take flight in large swarms. The following account of a flight in Columbia, S. C., has been communicated to me by Professor Baird, assistant secretary of the Smithsonian Institution:

COLUMBIA, S. C., *November* 18, 1876.

Prof. S. F. BAIRD, *Washington, D. C.*:

I inclose you specimens of "locust" which made their appearance on Friday, November 17, at about 9.30 p. m. Quantities could be gathered. I allowed my window to be used to exhibit them, and soon had to stop receiving them. I find they *are* locusts, from Wood's description, but find also that the same insect has been a denizen here for a long time, by reference to a dried specimen which I have had for six months. A week prior to their visit attention was called to the "specks," "meteors," "birds," &c., flying in front of the moon. I have no doubt they were an advance-guard of these locusts, as the under-wing is very brilliant in the light. I find they devour each other, but do not molest linen or cotton or paper in the window. I examined the fæces of the newly-arrived ones with the microscopes to judge of their last food, and found it to be *woody fiber*. The locusts were traveling from northwest to southeast.

Respectfully, &c.,

E. E. JACKSON.

Another swarm is described in the Monthly Report of the Department of Agriculture as "literally covering the streets" of Vevay, Ind., beginning to drop down at half-past 6 in the evening and continuing till 8 p. m. This species has also swarmed in Suffolk County, Virginia, according to Mr. C. R. Dodge.—(Rural Carolinian, quoted by Riley, Seventh Report.)

THE WESTERN CRICKET, *Anabrus simplex* Haldeman and *A. haldemani* Girard.—Very destructive to crops of wheat and other cereals and to grass; a large, stout, dark, cricket-like insect.

The "cricket" is especially injurious to crops in Utah, where it is very annoying and abundant. I have found it (*A. Haldemani* Girard, named by Mr. Scudder) common on the shores of the Great Salt Lake, where

the gulls were seen feeding on this insect as well as winged grasshoppers. Mr. Henry Edwards, under date of December 25, 1875, writes me as follows regarding the cricket: "I send you two specimens of the large brown cricket from Idaho. I think it is *Anabrus simplex* of Haldeman. It is extremely destructive to the crops of wheat and other cereals from Oregon to Wyoming Territory, and eastward to Montana, Idaho, and Utah. I do not think it has ever been found in California. When I was in Oregon two years ago, I made some few notes about this pest, and, if I can find them, will willingly place them at your disposal." Maj. J. W. Powell tells me that the cricket is annoying in Arizona.

I extract the following remarks on the geographical range and habits of the species of *Anabrus* from Professor Thomas's report in Hayden's Report on the Geology of Montana for 1871:

Anabrus purpurascens is found, not abundantly, but at certain elevated points from Northern New Mexico to Montana, along the east base of the mountains, but I have met with no specimen west of the range in the middle district, though Mr. Uhler gives Washington Territory as a locality on the authority of Dr. Suckley. It is also found as far south as Texas, and as far north as Red River, in Northern Minnesota. *A. simplex* appears to be confined to the middle district, as I have not met either in the eastern or western districts. Dr. Scudder, who examined the *Orthoptera*, collected by Professor Hayden, in Nebraska, does not mention it in his list; nor did Mr. C. R. Dodge have it among his collections made in Nebraska, Colorado, Kansas, and Indian Territory; nor is it among the collections in the Agricultural Department, made east of the Rocky Mountains. Hence I think we may safely conclude that it is confined to the west side of the range. But what it lacks in range is made up in numbers, for in the northern part of Salt Lake Basin and southern part of Idaho, the only points where I have met with it, it is to be seen in armies of myriads. (p. 431.) Found in great abundance between Brigham City, Utah, and Fort Hall, Idaho; also, occasionally met with farther south, in Utah, and north of Fort Hall, to the boundary-line of Montana, which is here along the range separating the waters of the Atlantic from the Pacific. At some points we found them so abundant as literally to cover the ground. In two or three instances they all appeared to be moving in one direction, as if impelled by some common motive. I recollect one instance, on Port Neuf River, where an army was crossing the road. It was probably as much as 200 yards in width. I could form no idea as to its length. I only know that as far as I could distinguish objects of this size (being horseback) I could see them marching on. I think that in all the cases where I saw them thus moving, it was toward a stream of water. They appear to be very fond of gathering along the banks and in the vicinity of streams. In the north part of Cache Valley I frequently noticed the ditches and little streams covered with these insects, which, having fallen in, were floating down on the surface of the water, and, though watching them for hours, they would flow on in an undiminished stream.

While encamped on a litte creek near Franklin, in this valley, it was with difficulty we could keep them out of our bedding; and when we went to breakfast, we found the under side and legs of the table and stools covered with them, all the vigilance of the cook being required to keep them out of the victuals.

But the strangest part of its history is that it will go in pursuit of and catch and eat the *Cicada*. This latter insect also made its appearance in this valley the past season in immense numbers, covering the grass and sage and other bushes, especially those which formed a fringe along the little streams. Up these the *Anabrus* would cautiously climb, reach out with its fore leg and plant its claw in its victim's wing; once the fatal claw secured a hold, the *Cicada* was doomed, for without ceremony it was at once sacrificed to the voracious appetite of its captor. No uniformity appeared to be preserved in this process; sometimes they would commence with the thorax, at others with the head, not even taking the trouble to remove the legs and wings.

I noticed in the road, where one of the armies was crossing, a number of large hawks feasting themselves upon the helpless victims. As I returned through Malade Valley (August 20, 1871,) the females were depositing their eggs. They press the ovipositor perpendicularly into the ground almost its entire length.

The following notes on *Anabrus simplex* have been obligingly prepared for this report by Mr. Henry Edwards, of San Francisco:

I know little of this species from my own personal observation. It was extremely abundant during a visit to Oregon some four years ago. I extract the following from my note-book: "The large brown cricket (*Anabrus simplex*) is a great trouble to the farmers of this region. (the Dalles,) and this year has been unusually common. It appears that they march to attack the corn fields in columns, and the only way left to the

farmers to protect themselves is to dig trenches around their fields into which the crickets fall in enormous crowds and are killed by their own numbers. The upper individuals, however, manage to make a bridge of the bodies of their companions, and sometimes cross the ditches in great quantities. Pigs eat these insects very greedily. They seem to be periodical in their appearance, the great swarms only occurring once in six years. I think their depredations are mostly committed in the night, as I saw none during the heat of the day, but toward twilight they swarmed on the stems of artemisia and other low plants, and were exceedingly active."

Description of Anabrus simplex.—Dark shining brown, posterior femora with an external and internal row of small spines beneath upon the posterior extremity; tibiæ angular, with a row of spines upon each side above, and two approximate rows beneath, with the spines alternating. Length, fifteen lines, pronotum six, ovipositor twelve, posterior femora and tibiæ, each eleven, and tarsi three and a half. This seems to be one of the species which is eaten by the aborigines of the Valley of the Great Salt Lake.—(Haldeman in Stansbury's Report, 1855, p. 372.

Anabrus haldemani Girard.—Antennæ long and filiform, reaching posteriorly the base of the ovipositor; pronotum short, broad; femora smooth, yellowish; feet and ovipositor reddish-purple. Posterior margin of pronotum black, with two parallel black bands on the posterior third of its length.

Description.—The abdomen above exhibits ten segments or articulations, the anterior or basal one being, as stated above, covered by the posterior prolongation of the pronotum. Beneath there are seven subquadrangular plates, situated opposite to the seven middle upper segments. The posterior segments inclose another piece bearing two spine-like abdominal appendages—one on each side. The ovipositor is as long as the abdomen, and entirely smooth. The base of the antennæ is situated above the eyes, and inserted upon an angular movable piece. The joints composing these organs are very short, and provided with minute setæ. The tibiæ are provided with four rows of spines, two anterior and two posterior; the internal posterior row being the stoutest. The posterior rows are more densely set with spines, while the latter are scattered and alternate with each other in the anterior rows. The first and cordate joint of the tarsi is the longest, the second is the shortest, and, from the middle of the third, a fourth slender and long joint arises, slightly convex above, and terminating in two spines or claws curved inward and outward. The ground-color above and below is yellowish; the antennæ, limbs, and ovipositor are of a reddish-purple. The posterior margin of the pronotum is black. Two parallel black vittæ, inclosing a narrow yellow one, are observed on each side of the dorsal line, upon the posterior third of the pronotum. The posterior portion of the upper abdominal segments is occasionally of a deep-brown hue.

This species differs from *Anabrus simplex* Hald., by a proportionally much shorter pronotum.—(Girard in Marcy's Report of Explorations on the Red River of Texas, p. 248.)

So large and conspicuous an insert as the Anabrus is easily kept under by the means already suggested in treating of the locust.

INSECTS SPECIALLY INJURIOUS TO WHEAT, OATS, BARLEY, ETC.

A.—Affecting the root and stalk.

THE JOINT-WORM, *Isosoma hordei* of Walsh, *Eurytoma hordei* of Harris.

A minute, footless, yellowish-white maggot forming blister-like swellings between the second and third joints of the stalk, immediately above the lower joint in the sheathing-base of the leaf; remaining through the winter in the stubble, straw, or harvested grain, and changing into a small, slender, black, four-winged insect, which deposits its eggs in the stalks of young wheat late in May and in June.

This insect, belonging to a group of chalcid flies which are, as a rule, parasitic on other insects, is a vegetarian, and parasitic on the stalks of wheat and other cereals, living on the sap, and by its presence causing the formation of blister-like galls or tumors on the lower part of the stalk. When the wheat or barley is from 8 to 10 inches high its growth becomes suddenly checked, the lower leaves turn yellow, and the stalks become bent. If the buts of the straw are now examined they will be found to be irregularly swollen and discolored between the second and third joints, and, instead of being hollow, are rendered solid, hard,

and brittle, so that the straw above the disease is impoverished, and seldom produces any grain. Suckers, however, shoot out below, and afterward yield a partial crop, seldom exceeding one-half the usual quantity of grain" (Gourgas as quoted by Harris). The worms have been found living in swellings, sometimes from six to ten in a tumor situated between the second and third joints, or immediately above the lower joint in the sheathing-base of the leaf, or in the joint itself. In November, in the New England States, the fully-fed larvæ as a rule (many do not until the spring) change to a chrysalis or pupa within the tumor, and in this state spend the winter in the straw or stubble or even in some cases in the harvested grain. In Virginia, the larva passes into the pupa state in February and March. From early in May until early in July, but mostly in New York in June, the four-winged flies issue from the galls, the males first appearing, and about the 10th of June, in Canada, the females deposit their eggs in the stalks of the young, healthy wheat. The larvæ hatch in a few days, and by the first week of July the young are nearly one-half grown. By the first of September the galls become hard and the worms fully grown.

I have endeavored to represent on the accompanying map the area of distribution of the joint-worm, but the area is probably too restricted. No facts are, however, at hand showing that it has occurred west of longitude 82° or south of latitude 36°, with the exception that a "joint-worm" is reported in the Monthly Reports of the Agricultural Department as having injured wheat in Kansas, but the species referred to has not, so far as I am aware, been referred to a competent botanist. I should be greatly obliged for specimens of this or any "joint-worm" from any part of the country.

The joint-worm of late years has been, so far as reports go, much less abundant than between the years 1825 and 1860, and it is to be hoped that it will not again be so prevalent. In former years the losses in Virginia amounted to over a third of the entire wheat-crop, while some crops in that State were not thought to be worth cutting. It was particularly abundant on rye, barley, and oats in the New England States and Canada, while in New York it was known to destroy one-half the barley-crop. Dr. Fitch has described several so-called species, allied to *Isosoma hordei*, and he supposed that they were restricted to different species of cereals. Mr. Walsh, however, has endeavored to show, with good reason, we think, that they were simply varieties of *I. hordei*, and that this well known species feeds upon all the small grains as well as wheat.

Either two or three specimens of ichneumon or chalcis flies, belonging to the same family (*Chalcididæ*) of hymenopterous insects as the joint-worm itself, prey upon the larva, and probably tend to reduce its numbers. Harris states that the larvæ of a species of *Torymus*, one of these chalcid flies, destroy the joint-worm. A species of *Torymus* (*T. harrisii* Fitch), perhaps the adult of the larval *Torymus* described by Harris, and a species of *Pteromalus*, also prey upon it.

Larva: The joint-worm is described by Harris, from specimens received from Virginia, as a round, cylindrical, footless, maggot-like worm, varying from one-tenth to three-twentieths of an inch in length. It is pale yellowish and without hairs. The head is round and partly retractile, with a distinct pair of jaws, and can be distinguished from the larvæ of the diptenous gall-flies by not having the usual V-shaped organs on the segment succeeding the head.

Adult: The imago or adult fly is a four-winged, hymenopterous insect, a member of the family *Chalcididæ*, most of which are insect-parasites. It is jet black, and the thighs, shanks (tibiæ), and claw-joints of the feet are blackish, while the knees and other joints of the feet (tarsi) are pale yellow; sometimes the legs are entirely yellow. The females are 0.13 inch in length, while the males are smaller, have a club-shaped abdomen, and the joints of the antennæ are surrounded by a verticil of hairs.

Remedies.—While the best way to encounter this insect is to breed and set loose the natural insect-parasites which prey upon it, the most obvious remedy is to burn the stubble in the autumn or early spring for several years in succession. If farmers would co-operate, this means would be sufficient to so reduce the numbers of this species that its attacks would be comparatively harmless. Plowing in the soil is of no use in the case of this insect, as the fly would easily find its way up to the surface of the ground.

THE HESSIAN FLY, *Cecidomyia destructor* of Say. (Plate LXV, Fig. 1.)

Two or three small, reddish-white maggots embedded in the crown of the roots or just above the lower joint, causing the stalks and leaves to wither and die; the maggots harden, turn brown, then resembling a flaxseed, and change into little black midges with smoky wings, which appear in spring and autumn, and lay from twenty to thirty eggs in a crease in the leaf of the young plant.

The Hessian fly was so called because it was first noticed as injurious to wheat during the revolutionary war, and was thought to have been imported from Europe in some straw by the Hessian troops. "It was first observed in the year 1776 in the neighborhood of Sir William Howe's debarkation on Staten Island, and at Flatbush, on the west end of Long Island. Having multiplied in these places, the insects gradually spread over the southern parts of New York and Connecticut, and continued to proceed inland at the rate of 15 or 20 miles a year. They reached Saratoga, 200 miles from their original station, in 1789. Dr. Chapman says that they were found west of the Alleghany Mountains in 1797; from their progress through the country, having apparently advanced about 30 miles every summer. Wheat, rye, barley, and even timothy-grass, were attacked by them; and so great were their ravages in the larva state that the cultivation of wheat was abandoned in many places where they had established themselves."—(Harris.) Dr. Fitch also thinks that this is an European importation, but Curtis in his "Farm Insects" doubts whether the European midge be of the same species. But it is reported by Köllar to have been known in Europe as early as 1833, and by later observers to be commonly diffused in Europe, and Köllar pronounces it as indigenous to Europe. Of late years it has not been reported to be so destructive as formerly, and no mention is made of it by the different State entomologists in their annual reports.

In the accompanying map showing the probable distribution of the Hessian fly and wheat-midge, I have been mainly dependent for my data regarding its distribution south and west of New York upon the Monthly Reports of the Agricultural Department at Washington. But the information there given, I regard as quite unreliable and unsatisfactory. It is quite likely that the Hessian fly may have been in those reports confounded with the wheat-midge and *vice versa*, or that when the "fly" is mentioned as injuring the wheat-crop, some other fly or insect has been the culprit. If, therefore, I have been in error, it will be from causes beyond my control. At the same time it is not unlikely that the area of distribution of both these insects may be found to coincide with that of each of the two, and with that representing the cultivation of wheat.* This latter has been taken from a map compiled

* Specimens of the Hessian fly, wheat-midge, and joint-worm, and notes on their habits and ravages, are earnestly desired by the writer for aid in improving and correcting the maps herewith presented. Specimens of this insect and the wheat-midge from all parts of the country are earnestly desired by the author.

by General Francis A. Walker, from the Statistics of Agriculture, Ninth Census, 1870.

This insect is double-brooded, as the flies appear both in spring and autumn. At each of these periods the fly lays twenty or thirty eggs in a crease in the leaf of the young plant. In about four days, in warm weather, they hatch, and the pale-red larvæ (Fig. 2*a*) "crawl down the leaf, working their way in between it and the main stalk, passing downward till they come to a joint, just above which they remain, a little below the surface of the ground, with the head toward the root of the plant." (Plate IV, Fig. 1*c*.) Here they imbibe the sap by suction alone, and by the simple pressure of their bodies, they become imbedded in the side of the stem. Two or three larvæ thus imbedded serve to weaken the plant and cause it to wither and die. The larvæ become full-grown in five or six weeks, then measuring about three-twentieths of an inch in length. About the 1st of December their skin hardens, becoming brown, and then turns to a bright chestnut color. This is the so-called flaxseed state, or puparium. In two or three weeks the "larva" (or, more truly speaking, the semi-pupa) becomes detached from the old case. In this puparium some of the larva remains through the winter. Toward the end of April or the beginning of May the pupa (Plate LXV, Fig. 1*b*) becomes fully formed, and in the middle of May, in New England, the pupa comes forth from the brown puparium, "wrapped in a thin white skin," according to Herrick, "which it soon breaks and is then at liberty." The flies appear just as the wheat is coming up; they lay their eggs for a period of three weeks, and then entirely disappear. The maggots hatched from these eggs take the flaxseed form in June and July, and are thus found in the harvest time, most of them remaining on the stubble. Most of the flies appear in the autumn, but others remain in the puparium until the following spring. By burning the stubble in the fall their attacks may best be prevented. Among the parasites on this species are the egg-parasites, *Platygaster* and *Semiotellus* (*Ceraphron*) *destructor* Say (Fig. 3), the latter of which pierces the larva through the sheath of the leaf. Two other Ichneumon parasites, according to Herrick, destroy the fly while in the flaxseed or semi-pupa state. The ravages of the Hessian fly have been greatly checked by these minute insects, so that it is in many localities not so destructive as it was formerly. Dr. Fitch has suggested that the European parasites of this insect, and the wheat-midge, could be imported and bred in large quantities, so as to stop their ravages. With proper pecuniary aid from the State this seems feasible, while our native parasites might perhaps also be bred and multiplied so as to effectually exterminate these pests. As regards the increase of parasites, B. Wagner, in his "Researches on the new Corn [wheat] Gall-fly" (Marburg, 1861), finds that the parasites of the Hessian fly increase in a ratio corresponding to that of their hosts. In the same year, he says, in which the hosts are very generally frequent, they are so infested by parasites that the next year only a few of the gall-flies appear. He also found that the parasites only infested the summer brood of Hessian flies, but not the winter brood; seventy per cent. of the former were found to be infested. Thus far the Hessian fly has not occurred west of the Mississippi Valley.

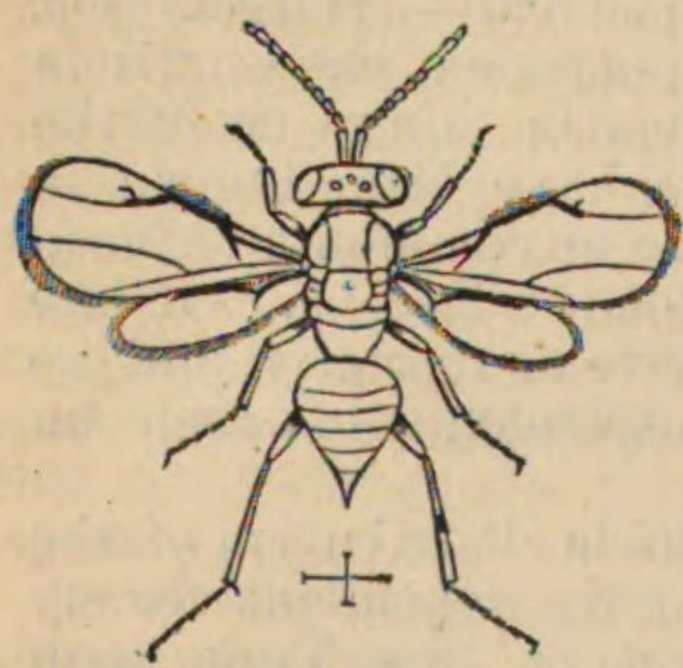


FIG. 3.—Parasite of the Hessian Fly.

Egg and larva: The egg is about one-fiftieth of an inch long and four-thousandths of an inch in diameter, cylindrical, translucent, and of a pale-red color (Herrick).

The larva or maggot when first hatched is pale reddish, afterward becoming white. It is when mature 0.15 inch in length, oval cylindrical, pointed at one end, and is soft, shining white.

Fly: Black with pale-brown legs and black feet and a tawny abdomen; the egg-tube of the female rose-colored, wings blackish, tawny at base; fringed with short hairs and rounded at tip. The body is about a tenth of an inch in length, and the wings expand one-quarter of an inch or more. The antennæ of the male have the joints roundish oval and verticillate.

Remedies.—Besides the parasites of this insect, its natural enemies, large numbers probably fall a prey to roving carnivorous insects and birds, particularly swallows and martins. As, however, the insect remains in the "flaxseed" state in the straw and stubble, the obvious remedy is to burn over wheat-fields for several years in succession. The rotation of crops is also a valuable preventive measure.

THE CHINCH-BUG, *Blissus leucopterus* of Uhler, *Lygæus leucopterus* of Say.

A small bug, while young sucking the roots of wheat and corn, afterward infesting in great numbers the stalk and leaves, puncturing them with their beaks. It appears early in June, and there is a summer and autumn brood, the adults hybernating in the stubble.

This is the most formidable enemy of wheat and corn, much more damage having been done to grain-crops in the Mississippi Valley and the Southern States than from any other cause, as it is more or less abundant each year. It is very abundant in Kansas, Nebraska, and California, according to Uhler. Dr. Shimer states that the female is "occupied about twenty days in laying her eggs, about 500 in number. The larva hatches in fifteen days, and there are two broods in a season, the first brood maturing, in Illinois, from the middle of July to the middle of August, and the second late in autumn." According to Harris, the "eggs of the chinch-bug are laid in the ground, in which the young have been found, in great abundance, at the depth of an inch or more. They make their appearance on wheat about the middle of June, and may be seen in their various stages of growth on all kinds of grain, on corn, and on herds-grass, during the whole summer. Some of them continue alive through the winter in their places of concealment." This species is widely diffused. I have taken it frequently in Maine, and even on the extreme summit of Mount Washington in August, but it is more properly a southern and western insect. It has not attracted notice on the Pacific coast, as M. H. Edwards writes me that it has not yet appeared in California. But as Mr. Uhler records it from California, it probably occurs there only rarely.

Dr. Shimer in his Notes on the Chinch-Bug says that it "attained the maximum of its development in the summer of 1864, in the extensive wheat and corn fields of the valley of the Mississippi, and in that single year three-fourths of the wheat and one-half of the corn crop were destroyed throughout many extensive districts, comprising almost the entire Northwest, with an estimated loss of more than $100,000,000 in the currency that then prevailed," while Mr. Walsh estimates the loss from the ravages of this insect in Illinois alone, in 1850, to have been $4,000,000.

In the summer of 1865, the progeny of the broods of the preceding year were almost entirely swept off by an epidemic disease, so few being left that on the 22d of August Dr. Shimer found it "almost impossible to find even a few cabinet specimens of chinch-bugs alive" where they were so abundant the year before. "During the summer of 1866 the chinch-bugs were very scarce in all the early spring, and up to near the

harvest I was not able, with the most diligent search, to find one. At harvest I did succeed in finding a few in some localities." This disease among the chinch-bugs was associated with the long-continued wet, cloudy, cool weather that prevailed during a greater portion of the period of their development, and doubtless was in a measure produced by deficient light, heat, and electricity, combined with an excessive humidity of the atmosphere." In 1868 it again, according to the editors of the American Entomologist, "did considerable damage in certain counties in Southern Illinois, and especially in Southwest Missouri." In 1871 Dr. Le Baron estimates the losses to corn and the small grains in the Northwestern States at $30,000,000, and Riley estimates the loss in 1874 in the same area as double that sum, the loss in Missouri alone being $19,000,000. Apparently no injury was sustained in Colorado in 1875 from this insect.

In the accompanying map showing the distribution of the chinch-bug, I have been mainly dependent on the statements of the State and other entomologists of the West, and the reports of the Agricultural Department. I have found the insect on the summit of Mount Washington, and argue from this fact that it is widely distributed over the colder as well as warmer portions of the New England States. It probably inhabits the entire United States east of longitude 100°, and will probably occur in the Western Territories, wherever wheat is raised, though perhaps the altitude and peculiar climatic features of the Rocky Mountain Plateau may prevent its rapid and undue increase.

Egg, young and adult.—The egg is minute, oval, 0.03 inch long, four times as long as broad, and white. The larva is at first pale yellow, afterward becoming red, changing with age to brown and black, and marked with a white band across the back. The adult is armed with a powerful beak, instead of jaws, with which it punctures the stems of plants and sucks in the sap; it sometimes abounds to such an extent as to travel in armies from field to field; it may be known by its white fore wings, contrasting well with a black spot on the middle of the edge of the wing, and is about three-twentieths of an inch in length. Certain individuals have very short wings.

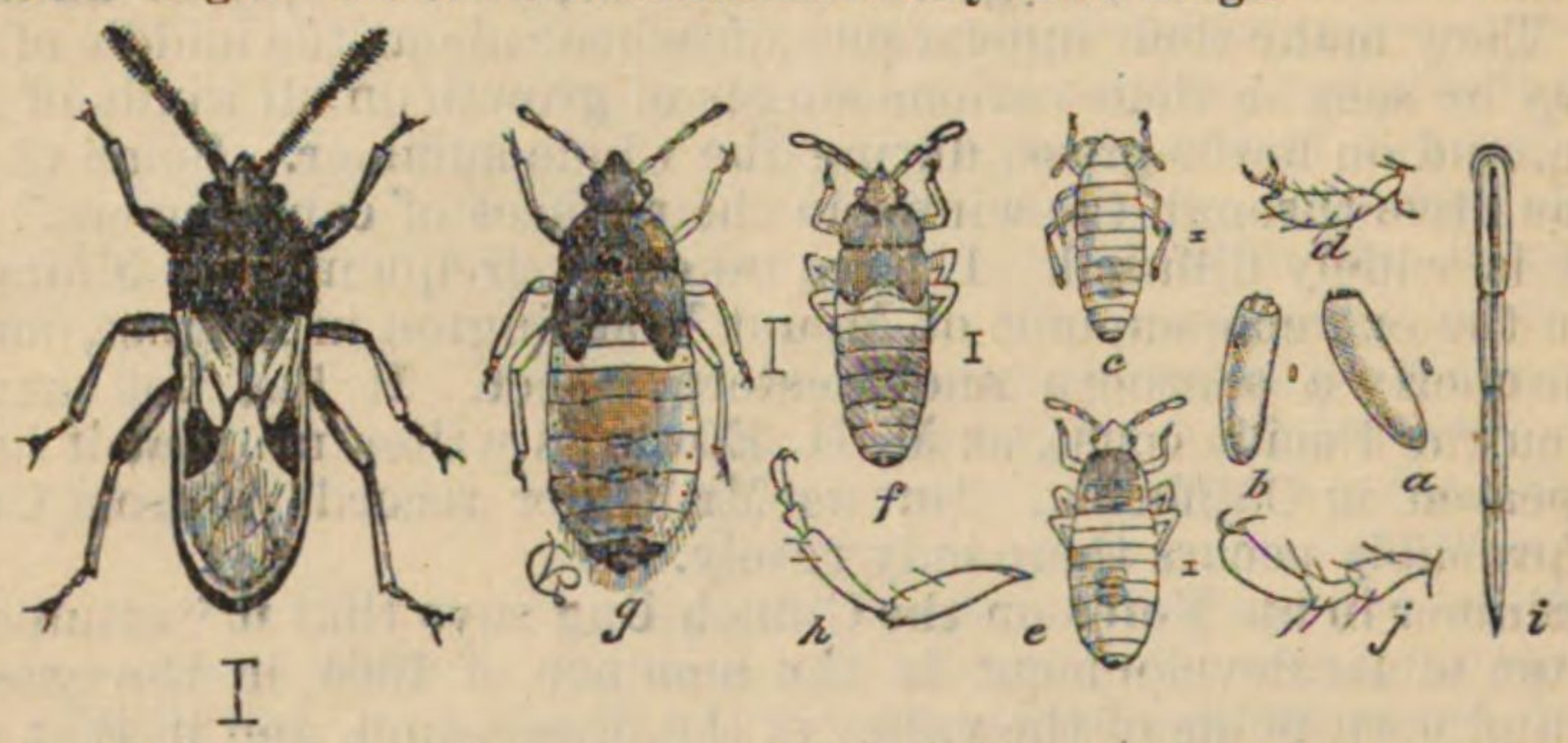


FIG. 4.—Adult and immature stages of Chinch-Bug.—*a*, *b*, eggs; *c*, newly-hatched larva; *d*, its tarsus; *e*, larva after first molt; *f*, same after second molt; *g*, pupa—the natural sizes indicated at sides; *h*, enlarged leg of perfect bug; *j*, tarsus of same still more enlarged; *i*, proboscis or beak, enlarged. (After Riley.)

Remedies.—Burn stubble, old straw, and corn-stalks among weeds in fence-corners in the early spring. Riley advises the early sowing of small grain in the spring, and suggests that the harder the ground is the less chance there is for the chinch-bug to penetrate to the roots of the grain and lay its eggs thereon. "Hence, the importance of fall-plowing, and using the roller upon land that is loose and friable." Heavy rains and cold, damp seasons reduce its numbers materially. Where irrigation is practiced, fields may be flooded for several days in

succession, and thus the insects driven off or drowned. The natural enemies of the chinch-bug are larger species of bugs, the lady-bird (*Hippodamia* and *Coccinella*), the larva of the lace-wing fly (*Chrysopa*), and quails, etc.

THE NORTHERN ARMY-WORM, *Heliophila unipuncta* of Grote; *Noctua unipuncta* of Haworth; *Leucania unipuncta* Guenée.

The summer of 1861 will be long remembered by agriculturists on account of the injury their crops received from the sudden and unprecedented appearance of a caterpillar which destroyed the leaves and heads of every sort of grain; and of a species of *Aphis*, or plant-louse, that gathered in immense numbers on the ears of the grain that had been left untouched by the army-worm, sucking out the sap of the ear, and thus lessening very materially its weight; or if in many cases not doing as much damage as this, causing much apprehension and anxiety to farmers generally.

The most injurious of these two insects is the larva of the *Leucania unipuncta*, one of a family of night-flying moths that embraces an immense number of species. The genus *Leucania* has a spindle-shaped body, a robust thorax, with a distinct collar just behind the head, which above is triangular, carrying near the base the thread-like antennæ, or feelers, which are about two-thirds the length of the wings. Two stout palpi, with a slender tip, project from the under side of the head, from each side of the hollow sucking-tube used to suck the sweets of flowers, but which at rest is rolled up between the palpi and rendered almost invisible by the thick-set, long hair-like scales that cover the head. A little behind the front margin of the thorax are placed the wings; the forward pair narrow and oblong, arched slightly at the apex, and just below, the outer oblique edge bulges out slightly. The outer edge or that farthest out from the insertion of the wing is in this genus two or three times as wide as the base. In the middle of the fore wing is a vein that runs out very prominent to just where it divides into three lesser branches; on this point in the species described below is a conspicuous white dot which gives it its name, *unipuncta*.

The hind wings are short, broad, and thin, just reaching out to the outer edge of the fore wing. There is a slight notch near the middle of the outer edge, and the inner edge, or that most parallel to the abdomen, is fringed with quite long hairy scales, that run into the pale fringe of the outer edge, which is always paler and broader than that of the fore wings. Both wings are much paler beneath, and do not show the markings of the upper side. When the moth is at rest, the hind wings are laid upon the abdomen and partially folded, so that the fore wings overlap one another above them like a roof. Thus folded, the ends of the wings are not much wider than the thorax.

The abdomen tapers rather rapidly, ending in a pencil of hairs. The second and third joints of the legs are much thickened, the last joints armed with minute spines, four of which are largest on the third joint.

Characters like these show moths of this genus to be strong and swift on the wing. In meadows and grass-lands, when disturbed they dart suddenly up from under our very feet and plunge into covert very quickly again. In the evening they fly in great numbers into open windows, attracted by the light within.

The eggs are laid near the roots of our wild, especially the perennial, grasses, such as timothy and red-top. Mr. Riley has succeeded in observing the female laying her eggs early in April at Saint Louis, Mo.

"By carefully watching, I have ascertained that the favorite place to which the female consigns her eggs in such grass is along the inner base of the terminal blades where they are yet doubled. The compressed horney ovipositor, which plays with great ease and tentative motion on the two telescopic subjoints of the abdomen, * * * * is thrust in between the folded sides of the blade, and the eggs are glued along the groove in rows of from five to twenty, and covered with a white, glistening, adhesive fluid, which not only fastens them to each other, but draws the two sides of the grass-blade close around them, so that nothing but a narrow, glistening streak is visible. * * * * The female, having once commenced to lay, is extremely active and busy, especially during warm nights, and I should judge that but two or three days are required to empty the ovaries, which have a uniform development. A string of fifteen or twenty eggs is placed in position in two or three minutes, and by the end of ten more I have known the moth to choose another leaf, and supply it with another string. Many must be laid very soon after vegetation starts, as some moths taken in the middle of April had already exhausted their supply; yet the bulk of them are not laid till toward the end of April." The hatching of the larva in a uniform temperature of 75° F. takes place from the 8th to the 10th day after deposition. The larvæ molt five times, and but three days while in confinement intervened on an average between each.—(Riley's Eighth Report.)

In Illinois, the moth lays its eggs in April and May, from four to six weeks earlier than in the Eastern States; so the larva appears earlier.

In Missouri, from the middle of April till the middle of May, and about the middle of June probably in Massachusetts, and a week later in Maine, the eggs placed in local and confined tracts of grass-land hatch their young larvæ, which for four weeks or thereabout feed incessantly till full-fed on the grass around the place of their birth, straying off as their forage is eaten up to fresh pastures.

The caterpillar state lasts for about a month, when it descends into the earth and changes to a chrysalis, remaining in this state two or three weeks. In Southern Missouri the moth appears about the fore part of June.—(Riley.) In New England the moth appears in

It is probable, according to the observations of Mr. Riley and myself, that while the majority of the moths appear in the late summer or early autumn, according to the latitude of the place where they live, a few may hybernate in the pupa state in the Middle States, and still more in the New England States. Mr. Riley thinks that the moths may sometimes lay their eggs upon newly-sown fall-grain.

We first hear of the army-worm when it is about an inch long; but it has eaten up all the grass around its place of birth, and in myriads is pushing out its columns after forage. The mature larva is about an inch and a half long. Its cylindrical body, divided into thirteen rings becomes more contracted and wrinkled at each end, and is sparsely covered with short hairs. The head is covered by a net-work of confluent spots, while along the middle of the face run two lines diverging at each end. A light-colored waved line just above the legs is succeeded by a dark one, then a light one edged with two thread-like lines; while the upper part is dark, with an interrupted white threadru nning exactly through the middle of the back. The prolegs, ten in number, are marked on their outer middle and on their tip with black. Beneath, the caterpillar is of a livid green.

Its name is suggestive of the regular, trained way in which myriads of these caterpillars march together in long, deep columns, side by side,

steadily over every obstacle, wherever their instinct leads them. Unlike the cut-worm, which moves by night singly, from field to field, and secrete themselves by day-time amid the roots of the plants they attack, the army-worm feeds in the forenoon and evening generally, scattered over fields of grain or grass, either eating the leaves or cutting off the heads and letting it fall on the ground. They will thus cut across the field, wantonly mowing off the heads of the grain. In this way, in Plymouth County, Massachusetts, they destroyed an acre and a half of wheat in one night, and then attacked a corn-field in the same way.

All young insects, or those in the larval stage, are exceedingly voracious; they eat surprising quantities of food. When these army-worms are shut up together without food, they will quickly devour each other. We give some extracts to illustrate what we have said, from the New England Farmer and Boston Cultivator. A writer in Danvers, Mass., says: "They were seen in great numbers through the entire field of several acres, climbing up the stalks of the barley, eating the blades and cutting off the heads of the grain. The day after these worms were discovered, the barley was mowed in order to preserve it, when they dropped to the ground, throwing themselves into a coil, a habit of the insect when disturbed. Many of them soon commenced a march for the neighboring fields and gardens, while others blindly pushed forward a column across the highways over a stone wall, where they were crushed by travelers on the road. But the main body marched to the adjoining gardens and inclosures, where the proprietors were waiting to receive them in their intrenchments, which had been thrown up a foot wide and two feet deep. The worms, as they fell in their advance into the trenches, were assailed in various ways by eager combatants, some spreading over them lime, tar, or ashes, while others resorted vigorously to pounding them. In this way, countless numbers of them were destroyed. The rear guard, composed principally of those of smaller growth, kept in the field, where they were picked up by a troop of fifty young red-winged blackbirds. I also noticed the robins feeding on these vermin." Again: "In adjoining lots they were commencing their devastation upon the corn, turnips, cabbages, weeds, and grass. They leave the grass-ground completely clean and white, so that it has the appearance of having been scorched in the sun. The cabbage and turnips they destroy by eating the tender parts of the plants, while they attack the corn by descending the spindle and concealing themselves in large numbers among the leaves where the corn is to make its appearance. Corn thus attacked, looks wilted and drooping. In some hills, the stalks were stripped of all their leaves. There were no worms upon the potato-tops, though they have killed all the grass to the borders of the field."

The damage done to crops in Western Massachusetts alone was estimated to amount to half a million dollars. In the Middle and Western States, the army-worm appears in numbers in certain years, and then are rare for some years. In Southern Illinois, in 1818 or 1820, they were more numerous than in 1861. They also appeared in 1825, 1826, 1834, 1841. In 1842 they were about as numerous as in 1861. In 1849 they were numerous in Southern Illinois. In 1856 they occurred in small numbers. In 1855 it appeared in Northern Ohio; in 1854 it abounded in Boone County, Missouri, and in 1865, 1866, and especially in 1869, in portions of the State. In 1871 it occurred in Illinois, and in 1872 in Iowa, Wisconsin, Ohio, and Kentucky, Illinois, Missouri, and Tioga County, New York.—(Riley.) Thus it is well known and established in the South and West, so that when it appeared in New York

and New England the past summer there were thought to be two species of army-worms. But the moths from different sections of the East and West have been compared and found to be the same. Dr. Fitch, also, has shown that "worms *in armies*," and "black worms," referred to by writers as occurring in New York and New England in 1743, 1770, 1790, and 1817, with habits like those of the army-worm of 1861, must be the same species. Mr. Sanborn assures me that he took the moth in 1855 near Boston; and has found the larva under stones in grass-plots. On Mr. Clark's farm at Carritunk, near the Forks of the Kennebec, the army-worm did a great deal of damage to the barley, in all destroying forty acres of grain. This was about the middle of August, and soon after the caterpillars entered the ground to transform. Their ravages were especially noticed, according to the Maine Farmer, in North Berwick, Union, Bangor, Ellsworth, and one or two other towns. Mr. Goodale informs us that on Mr. Joseph Clark's farm, in Waldoborough, the worm was found both in wheat and barley fields, though less on the wheat, which was riper. The leaves were consumed, while the heads were not much eaten. Many of the heads were cut off and had fallen upon the ground, while others were cut just enough to hang over. Mr. Goodale collected numbers of the worm on the 14th of August, and fed them till on the 20th all but one had gone into the earth. September 7, these millers appeared, and so several each day until the 16th. I have never taken this species in Maine until I met the worm in Bangor, August 2, in a yard a few rods from the Bangor House, and nearly full-fed; August 13, in a field of barley in Mattamiscontis, on the Penobscot, above Bangor. It was not seen on farms above this point on that river, or on the Allegash or Saint John, so far as I could ascertain, while the wheat *Aphis* was abundant on every farm I visited on those rivers. Whether the army-worm made its appearance for the first time in Maine in 1861 can be only probable. In Massachusetts it was first noticed the first of July; in Maine a month later, where it became generally prevalent.

The year 1875 was another army-worm year, and it abounded all over the country, especially in Missouri, Illinois, Delaware, Ohio, Kentucky, and Iowa, New York, and throughout New England, and in Western New Brunswick.—(Riley.)

While the caterpillar is single-brooded in the Northern States, in Saint Louis, Mo., Mr. Riley finds it to be double-brooded, and he thinks that three broods may sometimes appear in one season.

The following newspaper items will show the time of appearance and degree of damage done by the army-worm in New York, the New England States, and New Brunswick, in 1875:

Another insect-pest has made its appearance in formidable numbers on Long Island. The army-worm has been doing more damage in Suffolk and Queens Counties, especially the former, than even the dreaded potato-beetle. Corn and oats prove more attractive than potatoes to the army-worm, and in some instances the entire crop of oats has been destroyed. It is to be hoped that the recent heavy rains have put a stop to the operations of these caterpillars; at worst, their want of the power of flight will probably confine the damage to the island.—(New York Tribune, August 6, 1875.)

The army-worms have disappeared from Little Compton and Portsmouth as suddenly as they came. They did considerable injury.—(Boston Journal, August 13.)

A special from Rockland says that an immense army of black worms, similiar to caterpillars, were crossing Pleasant street in that city all day Sunday, heading southward. Large crowds gathered to witness their advance.—(Boston Journal, August 2.)

The Times says that the army-worm has appeared in Bath. This worm has appeared in Rockland, and as far east as Machias, and is reported as doing great damage.—(Brunswick Telegraph, August 10.)

SAINT JOHN, N. B., *August* 12.—The army-worms appeared on the marsh-road, a mile

from Saint John, yesterday afternoon, in considerable strength. Notwithstanding the efforts to destroy them, they were marching on the city last night with apparently undiminished numbers. To-day they are gone. Considerable damage was done to grass, turnips, and other root-vegetables. The army-worm recently invaded Grassy Island in Saint John River, from which an annual revenue was derived from the sale of grass. This year only one-fifth of the usual amount will be realized. There has been no general invasion of this province, and the alarm has subsided.—(Boston Journal.)

I have represented on the map showing the distribution of the northern army-worm, its probable range. Having received the moth from Texas, I think there is no reasonable doubt but that it also inhabits the other Gulf States as far as and including Northern and Middle Florida.

The army-worm appears in the wheat-fields when the "wheat is in the milk." Previous to this the young larvæ are not noticed. "When less than half an inch long, the worms are scarcely recognizable as army-worms," the general color being green and only feeding by night. Riley states that "in ordinary seasons they are reported along the thirty-third parallel, as in Texas, early in March, and about a week later with each degree of latitude as we advance northward. Then, in Southern Missouri they commence to march about the middle of May; in Central Missouri the first of June, and in the extreme northern part of the State about the middle of the month. In the more northern New England States they seldom do much damage before the middle of July (we should rather say first of August). There may, therefore, be a difference of over two months between the appearance of the worms in Southern Missouri or Kentucky and in Maine."—(Riley's Eighth Report.)

The pupa.—The middle of August, the larva, full-fed, descends into the earth a few inches, and there, by constant wriggling of its body and the excretion of a sticky fluid, constructs a rough earthen cocoon; or often it merely constructs a rude cell of dry grass just below the surface, and there in a day or two, probably, as is the case with most moths, the mahogany-colored pupa, nearly an inch long, with wing-covers reaching to the last third of the body, with two spines slightly curved in, situated on the last segment, emerges from the outer larva-skin or mask, and lying there ten or fifteen days, till the tissues of the future moth shall be formed and hardened, discloses the imago or moth the last of August.

Dr. Fitch shows that the natural habitat of the army-worm is in grass, in low lands. Mr. Riley substantiates Dr. Fitch's opinion, and thus accounts for the occasional undue increase of the caterpillar: "During an excessively dry summer these swampy places dry out, and the insect, having a wider range where the conditions for its successful development are favorable, becomes greatly multiplied. The eggs are consequently deposited over a greater area of territory, and if the succeeding year proves wet and favorable to the growth of the worms, we shall have the abnormal conditions of their appearing on our higher and drier lands, and of their marching from one field to another." * * * "Thus the fact becomes at once significant and explicable, that almost all great army-worm years have been unusually wet, with the preceding year unusually dry, as Dr. Fitch has proved by record."—(Riley's Second Report.)

In this, as probably in all other insects, the unusual prevalence of the individuals is due to unusually favorable conditions for the preservation of the egg and the development of the caterpillar and chrysalis. It should be borne in mind that in ordinary years, of the one hundred eggs laid by each moth (if that be the approximate number), but a small proportion hatch, being eaten by birds and possibly destroyed by egg-parasites and by cold and damp weather. Should fifty or seventy-

five worms hatch, probably only three or four perpetuate their kind; and so on throughout the insect-world. The struggle for existence is so great, each species suffering from adverse climatic causes and insect-enemies, that but a small proportion survive the perils of infancy and childhood, so to speak. Were it not so, the world would be overrun with prepotent animals and plants. The increase and great abundance of the few species are an indication of the intense struggle for existence by which the many alone maintain their livelihood.

Remedies.—If lands are burned over in the dead of the year where these eggs or pupæ or moths abound, which is the best remedy we can apply to keep off or kill off this moth, the fire will certainly kill the chrysalids just below the roots of the grass, as it surely will the eggs on the stalks or the moths nestling among them. Tracts of land in Maine thus burned over in the spring of 1861 escaped the army-worm in the summer, while farms near by suffered from the incursions of worms from the unburned grass-lands around.

Ditching, or making a deep trench with steep or undermining sides, especially efficacious in sandy soils, will do much toward keeping them out of fields of grain. People have also laid tar in the bottom of ditches, laid trains of guano, and made bonfires in them. By turning fowl and hogs into fields just as the caterpillar is going into the earth to pupate, great numbers can be destroyed, and the hogs and hens will grow fat on them.

Enemies.—That birds of different kinds feed on these caterpillars has been noticed. There are also night-birds that catch the moths as they fly. Both the larva and moth are exposed on every hand to the attacks of other insects, such as the dragon-flies, which are continually on the wing, especially over low lands. A large purple beetle with rows of golden spots on its wing-covers, the *Calosoma calidum*, which is very common in grass-lands, either running about after their prey, or lying on the watch in their holes among the grass, makes great havoc among the army-worm, and not only the beetle, but its larva, which is more voracious, if possible.

Ants are known to destroy the army-worm. I am indebted to Mr. H. I. Hershs, of Richmond, Ind., for the following instance: "In June, 1875, the army-worms took possession of a grass-plot near my study-window, and for a time threatened to strip it of every vestige of green; but I noticed a few days after they made their appearance that a large number of small black ants were waging a war of extermination against them, which, in conjunction with the unusually wet weather, soon put a stop to their depredations."

But undoubtedly the grand check that nature has imposed upon the too great increase of caterpillars are their parasites, or those ichneumon-flies belonging to the great order *Hymenoptera*, and two species of *Diptera*, or true flies, which lay their eggs on the outside of the caterpillar. The young hatching out feeds on the fatty tissues of the caterpillar, which lives just along time enough for the parasite within to come to maturity. The larger ichneumons only live singly in the body of the caterpillar, while as many as a hundred of the minute species have been seen to emerge from the dead larva-skin, their cocoons placed side by side within.

We first notice a large species which Mr. Shurtleff raised from the army-worm between the first and middle of September.

Ophion purgatus Say. This genus of ichneumons has a slender body, with long filiform antennæ. The thorax above oval, and as wide as the head. The legs are long and slender; but the most apparent

character is the long compressed abdomen, which, much arched or sickle-shaped, is attached to the body by a slender peduncle. The end of the abdomen is cut off obliquely inwards below. The ovipositor is scarcely to be seen, which in most ichneumons is very long; and here we see the adaptation of this organ to the habits of the species. Instead of piercing the body of the victim and depositing the egg at the bottom of the wound, the *Ophion* merely lays its egg on the skin of the caterpillar. The egg is bean-shaped and attached by a pedicle to the skin. When the footless grub is hatched it does not entirely leave the egg-case, but the last joints of its body remain attached to the shell, while it reaches out over and with its sharp jaw-pieces gnaws into the side of the caterpillar. Some *Ophions* are parasitic in their ichneumons, just as are the species of *Chalcis* mentioned below.

This species, common in Maine, is of a pale-reddish horn color. The head is yellow, pale testaceous at the base of the antennæ. The large prominent eyes black. Three smaller black simple eyes are arranged in a triangle above, between the compound eyes. The rest of the body, especially the hind part of the thorax, and the joints and under side of the abdomen and legs beneath are covered by a bloom of minute lighter-colored hairs which have their origin in microscopic punctures. On the middle of the thorax above, a little darker; and behind, a yellowish tint. Next the insertion of the abdomen the thorax is thickly and plainly punctate. Same color beneath, except the first three joints of the abdomen, which are touched with yellow, and the lower side is generally darker.

The veins of the wings are dark; the thickened cell on the front margin of the fore wings and the adjacent veins as well as the horny triangular pieces in the cell below, the outer of which is much the smallest, are pale horn color.

Body nearly an inch long. Expanse of wings, 12½ tenths.

Mr. Walsh, of Illinois, has discovered three other ichneumons, descriptions of which we take from his pamphlet:

Mesochorus vitreus Walsh.—Male, general color light rufous. Eyes and ocelli black, antennæ fuscous except toward the base. Upper surface of thorax in the larger specimen fuscous; intermediate and posterior tibiæ with spurs equal to one-fourth their length; posterior knees slightly dusky; tips of posterior tibiæ distinctly dusky. Wings hyaline, nervures and stigma dusky. Abdomen viewed in profile, curves considerably, especially at base, and is quite narrow, except toward the tip, where it expands suddenly. The abdomen of the male is appendiculated. It is of a translucent yellowish-white in its central one-third; the remaining two-thirds piceous black, with a distinct yellowish narrow annulus at the base of the third joint. Appendiculum of abdomen composed of two extremely fine setæ, thickened at their base, whose length slightly exceeds the extreme width of the abdomen.

The female differs in the head, being from the mouth upward piceous. The thorax and pectus are piceous black. Ovipositor, which is dusky, slightly exceeds in length the width of the abdomen. Body, .08-.03 inch long.

Pezomachus minimus Walsh.—This genus is wingless, like the neuters of ants, except that their antennæ are not elbowed like those of ants.

Male, piceous. Eyes black, antennæ black, except toward the base, where they are light rufous. Legs rufous, hinds legs a little dusky. Abdomen narrowed; second and sometimes third joint annulate with rufous at tip. The female differs in the thorax, being almost invariably rufous, and in the first three abdominal joints being generally entirely rufous, with a piceous annulus at the base of the third, though sometimes absent. The abdomen is also fuller and wider. Ovipositor dusky, equal in length to the width of the abdomen. Body .07 to .1 inch long.

The cocoons symmetrically arranged side by side, and enveloped in floss, are found in the dead skins of the army-worm. A minute ichneumon, *Chalcis albifrons* Walsh, was bred from the cocoons of the *Pezomachus*.

Microgaster militaris Walsh, is another army-worm parasite. Head black; palpi whitish; antennæ, fuscous above, light brown beneath toward the base. Thorax black, polished with very minute punctures. Nervures and stigma of the wing fuscous. Legs light rufous, posterior pair with knees and tips of tibiæ fuscous. Abdomen black, glabrous, highly polished. Ovipositor not exserted. Length of body, .07 inch.

Two parasites live in this microgaster, *Hockeria perpulchra* and *Glyphe viridescens*, belonging to the *Chalcid* family of ichneumons. Walsh says:

We now know that of 145 ichneumon-flies, promiscuously taken, that had depredated on the army-worm, 27, or only 18 per cent., perished by *Chalcis* flies.

Ichneumon leucaniæ Fitch.—Dr. Fitch has given an account of another ichneumon.

This parasite resembles a small wasp, nearly half an inch long, of a bright rust-red color, its wings smoky, its breast black, and also the middle of its back, where is a small bright sulphur-yellow spot, which is the scutel. The antennæ have a milk-white band on their middle, below which band they are rush-red, and above it black. There are two narrow bands also on the back of the abdomen, placed on the fourth or fifth joint, and the slender peduncle of the abdomen is also black. Mr. Sanborn has raised this same species, as also another ichneumon, which we describe.

Ichneumon species.—Ichneumons of this genus are rather slender-bodied; the abdomen long oval. Wings not much longer than the slender antennæ, which in turn are a little more than one-half the length of the whole body. The legs and joints of the feet are also slender. The ovipositor of the female is not apparent; her eggs are pedunculated, having a general likeness to those of the genus *Ophion*.

The species before us is black and yellow. Head: face square, yellow; a dark line borders the base of the antennæ, which are rusty, the first joint yellow, and the ends dusky. Head behind the antennæ black. Thorax black; above on its first joint, or prothorax, a yellow transverse elliptical. On the second joint which carries the fore wings are two yellow stripes forking toward the head. Scutellum yellow; another transverse elliptical yellow spot behind. Third joint of thorax yellow above, black beneath. Legs: first and second pairs yellow, reddish above on first joint. Third pair black at base; second joint yellow; third, or femur, black; fourth, or tibia, black at tip. Tarsi, or toes, marked with black.

The elbowed abdomen black at base, the elbow yellow. The next three yellow joints with a narrow black strip on the front edge, the hinder edge of the ring tinged with reddish. Last three rings black.

Our last parasite is a fly, or species of the *Tachina* family, that Mr. Shurtleff and Sanborn have both raised from the army-worm, and I find it to be identical with the species that attacks the worm in the West.

Exorista leucaniæ Kirkpatrick (*Senometopia militaris* Walsh).—This genus resembles in form our common house-fly. The thorax is usually striped longitudinally, and the whole body covered with large hairs. It flies low in sunny spots in woods, with a loud buzzing noise. We copy Mr. Walsh's description, and select some interesting information he gives us about its habits:

Length, .25 to .40 inch; the females not exceeding .30 inch. Face silvery, with lateral black hairs only on the cheeks, at the top of which is a black bristle. Front golden olive, with a black central stripe, and lateral black convergent hairs. Occiput dusky. Labium, brown, with yellowish hair. Maxipalps, rufous. Eyes, cinnamon-brown, covered with very short dense whitish hair. Antennæ, two basal joints, black, with black hairs; third joint flattened, dusky, and from two and a half to three times the length of the second joint; seta, black. The entire hinder part of the head covered with dense whitish hair. Thorax glabrous, bluish-gray and lighter at the sides, with four irregular black vittæ, and black hairs and bristles. Scutel, reddish-brown, whitish behind, glabrous, with black hairs and bristles. Pectus, black, glabrous, with hairs and lateral bristles; legs, black, hairy; thighs, dark cinereous beneath; purvilli, cinereous. Wings, hyaline; nervures, brownish; alulæ, opaque greenish-white. Abdomen, first joint black; second and third, opalescent in the middle, with black and gray, and at the sides with rufous and gray; last joint, rufous, slightly opalescent at base with gray; all with black hairs and lateral bristles.

Beneath, the first joint is black; the others, black marginal with rufous, all with black hairs. In the male, the space between the eyes at the occiput is one-seventh of the transverse diameter of the head; in the female, it is one-fourth.

Some pupa-cases of this fly before me are a little more than a quarter inch long; cylindrical; rounded at each end. The last segment, barely

distinguishable, has two little flattened plates that were the breathing-pores in the larva. The two first segments are partially split off, and ruptured across the end, where the fly burst out. The fly appeared the 20th of September.

"The eggs," Mr. Walsh says, "are much the shape and color of those of the flesh-fly. The fly fastens its eggs by an insoluble cement on the upper surface of the two or three first rings of the body. Instinct appears to teach the mother-fly that if she places her eggs further back, the little maggots, as they hatch out and begin to penetrate the flesh, will be felt by the victim and seized by its powerful jaws, as I have seen wood-feeding caterpillars seize and worry like a dog ants that attacked them."

Mr. Walsh had fifty or sixty worms, of which all but two had their eggs, from one to six in number, fastened on their upper side. From these he bred fifty-four *Tachinas* and two moths. "Now these army-worms averaged about three eggs apiece, and consequently two-thirds of the eggs of the *Tachina* must have perished without arriving at maturity."

"My *Tachina* eggs, so far as I noticed, did not hatch till the larva had gone under ground; but from information received from Mr. Emery, I have reason to believe that, under certain circumstances, this, or an allied species, hatches out above ground, adhering externally, and 'growing rapidly, while its victim decreases in size.' They uniformly devoured the larva before it transformed into the pupa state. The time for the entire transformation of such as I experimented upon from egg to fly, was from fifteen to nineteen days." * * * "Jefferson Russell, an intelligent farmer, had repeatedly, on damp, cloudy mornings, watched a large, bluish-green fly, about the size of a blow-fly, attacking the army-worm, and depositing its eggs on the shoulders of the victim, as he ascertained by a double lens. As they were attacked, the army-worms kept dropping to the ground and gathering in clusters, or hiding under clods, until finally the wheat on which they occurred was entirely free from them." Mr. Riley says that in 1875 fully 80 per cent. of the army-worms which he noticed were attacked by the *Tachina* flies. "They never abound or travel from one field to another, but they are accompanied by a number of two-winged flies, which are often so numerous that their buzzing reminds one of a swarm of bees."—(Eighth Report.) This fact supports the opinion of Wagner (see p.) that insect-parasites usually increase in proportion to their hosts.

Egg.—When first laid, spherical, 0.02 inch in diameter, smooth, opaque white; covered with a glistening, adhesive fluid; shell delicate, becoming faintly irridescent and more sordid before hatching.—(Riley.)

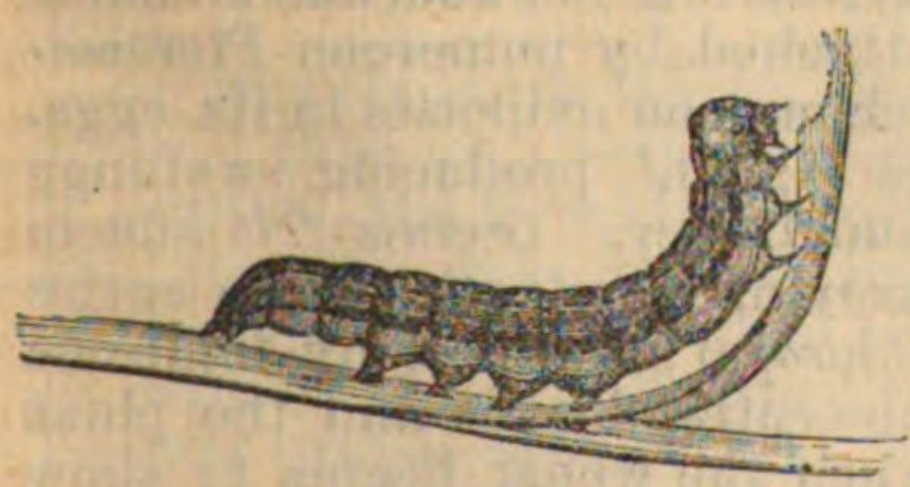


FIG. 5.—Full-grown Northern Army-worm.

Larva.—When first hatched, 1.7 millemeter in length; dull white, and a large dark head.

In the first and second stages, the two front pairs of abdominal legs are atrophied so as to necessitate a looping gait. In the third stage the looping habit is lost, but the front abdominal legs are still somewhat the smallest. In the fourth stage, the color is dull, dark green, and the chameleonitic brown lines appear.—(Riley.)

FIG. 6.—Pupa or Chrysalis.

The mature larva is about an inch and a half long. Its cylindrical body, divided into thirteen rings, becomes more contracted and wrinkled at each end, and is sparsely covered with short hairs. The head is covered by a net-work of confluent spots, while along the middle of the face run two lines diverging at each end. A light-colored waved line, just above the legs, is succeeded by a dark one; then a light one, edged with two

thread-like lines; while the upper part is dark, with an interrupted white thread running exactly through the middle of the back. The prolegs, ten in number, are marked on their outer middle and on their tip with black. Beneath, the caterpillar is of a livid green.

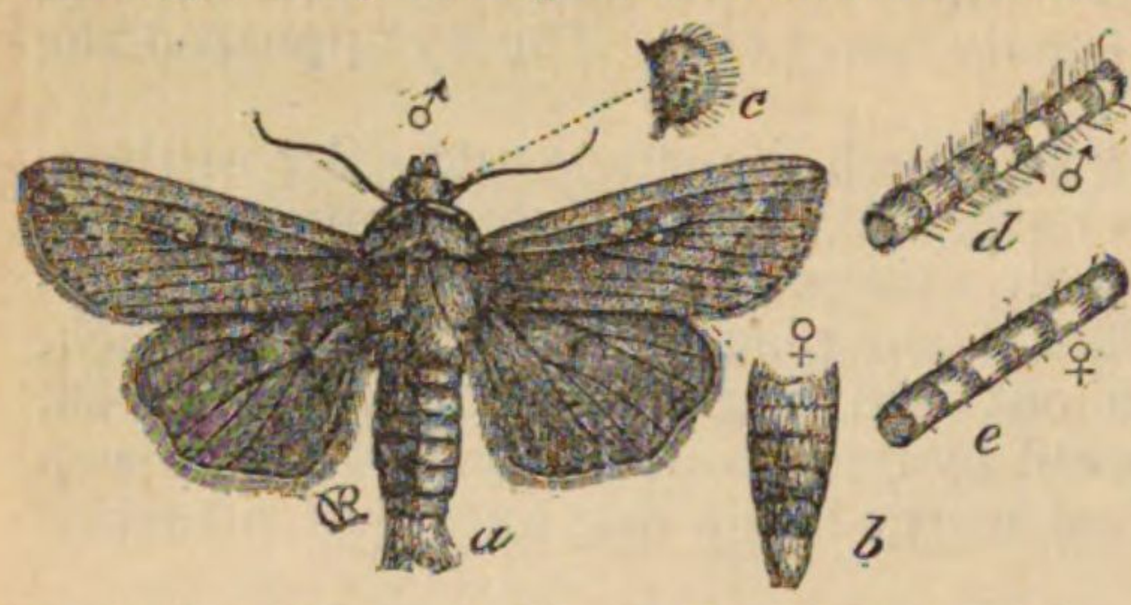


FIG. 7.—*a*, male moth; *b*, abdomen of female—natural size; *c*, eye; *d*, base of male antennæ; *e*, base of female antenna; enlarged.—(After Riley.)

Most of the Maine species of *Leucania* have light-colored wings, with dark streaks and dots, but the *unipuncta* is larger and darker colored. Its prevailing hues are rusty grayish-brown, sprinkled or peppered sparsely with black scales. The upper part of the head, the front part of the thorax or collar, and front margin of the fore wing, are of a lighter shade. Between the front margin of the fore wing and the vein, or raised line reaching out to the white spot in the center, is a rusty patch. Just beyond, about half-way between the white dot and the outer edge, is a row of about ten black dots, situated on the veins, running toward the apex of the wing, but the last three are deflected at a right angle inward and up to the front margin, while a dark line starts from the corner or curve in the line of dots, and proceeds to the upper angle or apex of the wing. The little veins of the outer edge are silvery, and between them, in a row next to the fringe, can just be seen little black dots.

The hind wings are pearly smoke-colored, darker toward the outer edge, with a central spot of the same color, which can be seen on the under side.

Beneath, the moth is a light pearly-gray. The fore wings are clouded in the middle, with a dark spot on the front margin, one-fourth of the way from the tip. The fore wings are rather more pointed in this species than the other. The body measures nearly an inch long, and the wings expand a little over an inch and one-half.

Summary.—The army-worm moth appears late in the summer or early in the autumn, when it hybernates, after laying its eggs near the roots of perennial grasses; or it hybernates in the chrysalis state and oviposits in April and May southward; later, northward. The eggs hatch and the young appear eight or ten days after, and the worms are most destructive in wet summer succeeding a dry one, when the "wheat is in the milk." The caterpillar state took a month; the chrysalis state two weeks. The species is mostly confined to the Middle and Northern States. Besides external enemies it has eight internal parasites. The best way to exterminate the worm is to burn meadows and grass-lands, where the insect lays its eggs, in the autumn.

EUROPEAN WHEAT-FLIES.—Several very destructive flies are known in Europe to injure the stalks and leaves of wheat and other cereals, and as they are liable to be imported into this country, I will refer to them. The *Oscinis granarius* in England lives in the stalks of wheat; *Oscinis vastator* in Europe damages wheat and barley by eating the base of the stalk. The larva becomes fully grown late in June, and a month later the fly appears. It is said to be attacked by numerous *Pteromalus* parasites, and a minute *Prototrupid* ichneumon oviposits in its eggs. Allied species causes the disease called "gout," producing swellings twice the size of the stalks of wheat and barley. *Oscinis frit* affects the ears of barley, in certain years destroying one-tenth of the entire crop. Two species of another genus (*Chlorops*) are especially injurious in Europe. *Chlorops lineata* destroys the central leaves and the plant itself, the female ovipositing on stems when the wheat begins to show the ear. In two weeks the eggs hatch and the fly appears in September. *Chlorops herpinii* attacks the ears of barley, from six to ten larvæ being found in the ears, destroying the flowers and rendering them sterile. In dealing with these insects plowing in has been found to be of no use, and the best preventive measure is the rotation of crops.

THE COMMON WHEAT-FLY, *Chlorips vulgaris* Fitch.—Certain small, slender, pale-green and watery-white shining maggots belonging to the above species with the others mentioned below are said by Dr. Fitch to burrow in different parts of the stalks, dwarfing and often killing them.

It was not until 1855 that it was known that wheat in this country was affected by these maggots, when they were discovered by Dr. Fitch, who thinks that it is from the number of these and other insect depredators that farmers are not now able to raise such large crops as used formerly to be harvested. The *Chlorops vulgaris* is abundant the latter part of June in wheat-fields. It is pale yellow, and 0.15 inch in length. Another fly is the *Meromyga americana* of Fitch. It is yellowish-white and a little larger than the preceding. Another minute fly, found in company with the others, is the *Liphonella obera*. It is less than a line in length and is jet-black. Still another form found in the heads of wheat in New York in June is *Oscinis tibialis*. It is only 0.08 inch in length, and also jet-black, with pale dull-yellow shanks and feet. The last fly mentioned by Fitch is *Hylemyia deceptiva*, which occurs in abundance upon heads of wheat late in June. It is ash-gray, with black legs and feelers, and a quarter of an inch in length.

INJURING THE HEADS.

THE WHEAT-MIDGE, *Diplosis tritici* of recent authors; *Cecidomyia tritici* Kirby.—Several minute orange-red maggots, one-eighth of an inch long, crowding around the kernels of wheat, causing them to shrivel and dry when ripe. The maggots descend into the ground and spin minute cocoons, from which in the following June come bright orange-colored midges.—(Fitch.)

This insect was probably imported into Quebec about the year 1820. It made its way along the Saint Lawrence and Chambly (Sorelle) Rivers into Northwestern Vermont, and soon became so abundant in New England and New York that the cultivation of wheat was mostly abandoned. Its attacks then decreased, and wheat was again raised until in the year 1854, when wheat was largely in cultivation, it again became very destructive, causing a loss in the State of New York alone, according to the estimate of Dr. Fitch, of $15,000,000. In Canada, in 1856, the loss was estimated to exceed $2,500,000. In the same year, in portions of New York, the midge destroyed one-half to two-thirds on the uplands, and nearly all on the lowlands, and the destruction was worse in 1857 and 1858. In 1858 very little white wheat was sown in Western New York, and the midge reduced the value of all the wheat-lands at least 40 per cent. In 1859 the midge unaccountably disappeared, to again become prevalent in 1861.—(Fitch.) Mr. Riley, in the New York Tribune, refers to this insect as infesting wheat in Indiana during the summer of 1876.

As regards the habits of the wheat-midge, I reproduce the following account from my "Guide to the Study of Insects:" "When the wheat is in blossom, the females lay their eggs in the evening by means of the long retractile tube-like extremity of the body within the chaffy scales of the flowers, and in clusters of from two to fifteen or more. In eight or ten days the eggs disclose the transparent maggots, which, with age, become orange-colored, and, when fully grown, are one-eighth of an inch long. They crowd around the germ of the wheat, which, by pressure, becomes shriveled and aborted. At the end of July and in the beginning of August, the maggots become full-fed, and in a few days molt their skins, leaving the old larva-skin entire, except a little rent in one end of it. 'Great numbers of these skins are found in the wheat-ears immediately after the molting process is completed.'

Sometimes the larva descends to the ground and molts there. Harris states that 'it is shorter, somewhat flattened, and more obtuse than before, and is of a deeper yellow color, with an oblong greenish spot in the middle of the body. In this state, which is intermediate between the larva and pupa states, which has, by Dr. Fitch, been termed the "embryo-pupa" and by us "semi-pupa," the insect spins a minute silken cocoon, which, according to Dr. Fitch, is smaller than a mustard seed, and remains in the ground through the winter, situated at the depth of an inch beneath the surface. In the next June they are transformed to pupæ, with the limbs free. When about to assume the adult state, the pupa works its way to the surface in June and July.'"

Description.—The eggs of the wheat-midge are long, oval-cylindrical, and tinged with pale red. When the larva is at rest it is oval, flattened on the under side, deep yellow, and 0.08 inch long. The female fly is nearly one-tenth of an inch long, bright orange or lemon-yellow, and tarnished or slightly smoky on the back forward of the wings, the latter clear, with a small cross-vein near their base; the antennæ are about as long as the body, and composed of twelve oblong joints, which are narrower in their middles and separated by short pedicels. In the males the antennæ are remarkably long, slender, and delicate, and consist of twenty-four globular joints; it is smaller, but in other respects agrees with the female.—(Fitch.)

Parasites.—Dr. Fitch has shown that when the midges increase or diminish in numbers its parasites increase or diminish in the same ratio, "the same as the Hessian fly, once so frightfully destructive to our wheat-crops here in America, has become subdued by its parasites, whereby it is seldom noticed now or known to be present in our country, although it can be found almost every year in our wheat-fields, showing it is still with us, everywhere ready to again increase and become destructive were it not constantly repressed and kept down by its parasitic foes." Mr. Curtis is quoted as saying that in Europe "these parasites so effectually execute their mission, that it has often happened a year or two after the midges were in excess not a specimen could be found." Its destructiveness in this country is due to the fact that we have no native parasites to keep it within proper limits, and Dr. Fitch urges that the parasites be imported from Europe.

GRAIN-APHIS, *Aphis avenæ* Fabricius.—Multitudes of dark plant-lice, clustering on the heads of wheat in August, blackening the fields of grain, and, by sucking the kernels, causing them to shrink in size and diminish in weight.

We will suppose a number of eggs to hatch out their wingless females; with an occasional winged individual there are as yet no males in existence, and yet these virgin aphides, or plant-lice, every few days produce hundreds of young alive; each of which in turn come to maturity and produce their young alive. Hence, by the end of summer we have millions of lice overrunning our wheat-fields, the very youngest as well as the oldest as if for their lives sucking in the sap from the ear of the grain. For by a marvelous adaptation to their mode of life, what in beetles are jaws for biting are here lengthened out and joined together to form a tube, with a sucking-stomach at the base. This tube the louse forces into the root of the ear, and thus anchored by their jaws, whole groups cluster head downward on the heads of grain, and by their numbers color a whole field. But the supply of liquid food is greater than the aphides can manage, hence two tubes open out from the hind part of the abdomen, from which exudes a sweet sticky fluid called "honey-dew." Ants come to eat it as it falls on the leaves, or lap it from the honey-tubes of the aphis, and as the supply lessens, they gently strike the aphis with their antennæ to make them yield more.

At the approach of cold weather, when the whole race of aphides

must be cut off, the virgin females produce winged individuals of both sexes, which after pairing die, after depositing their eggs for the spring brood.

Our species is oblong-oval shaped, narrowing toward the head, while the abdomen behind is swelled out and rather blunt at the end, with a rather long ovipositor in the female. Its color is green, covered often with a reddish-brown bloom. The ends of the antennæ, the end of the shanks and thighs and the feet, are black. In the young, these parts are only smoky or dusky. Length of those with wings about one-tenth of an inch.

Dr. Fitch gives in the Boston Courier, interesting observations on this aphis. Of its variation in color he says: "One of the most remarkable circumstances relating to these insects is the change in their color which now began to take place. While they were scattered about upon the leaves and stalks of the grain, they were of a bright grass-green color. Now orange-yellow or deep flesh-red individuals began to appear among them. This color is so wholly different from green, that these orange ones might be suspected to be a different species. But green females placed in vials were found next day to have young with them of both colors; some being green, others orange. And a few days later other green females were found to have orange young only, no green ones being born any longer. It is probably the change in the quality of its food which causes the insect to change thus in its color, the juices which the plant elaborates for the growth of its flowers and seeds being much more highly refined, nutritious, and dainty than those which circulate in the stalks and leaves, where the insect first feeds. And it is truly curious and wonderful that this green-colored insect, on coming to feed on the juices which grow the flowers, begins thereupon to give birth to young having a gray orange color similar to that of the flowers."

Dr. Fitch noticed several years ago in wheat-fields a green plant-louse, though it was not common.

In East Hampden, Mass., "a plant-louse of a pale brick-red color was extremely numerous" in 1860; so, also, a "red insect" on the oats in New York was sent him. We thus know the insect we are to speak of was overrunning the fields in some places last summer.

"Early in May last, when rye and winter-wheat were but a few inches out of the ground, I met with this insect more numerous than any other in every part of every grain-field in my neighborhood. Toward the close of that month specimens having wings began to occur. By inclosing them singly in vials, I found that the winged female usually gave birth to four young lice in twenty-four hours, while those without wings produced eight within the same time."

The grain-aphis became noticed the 18th July in New Jersey, then in the New England States. Probably very few farms in Maine escaped its presence. About the first of August I noticed them on a farm about thirty miles above Mattawamkeag, on the Penobscot River. Also on farms on the lakes that form the headwaters of the Penobscot and Alleguash Rivers, and on the Alleguash and Saint John. I also heard of its occurrence in great numbers on the Saint John in New Brunswick. Like the army-worm, while abundant on some fields, others were entirely free from its attacks.

The injury this aphis does is to lessen the weight of the grain, which of course is a matter of great consequence. The constant draining of the sap that flows into the ear causes it to be very light, if not withered and worthless.

Parasites.—Artificial means of driving off this pest have not yet been contrived. It has been suggested to kindle fires, throw on damp straw, and let the wind carry the smoke over the field.

But the external enemies of this aphis are ready to help us. The lady-bugs, *coccinella*, as larvæ and beetles, the golden-eyed flies, *chrysopa*, as larvæ, have been seen the past season in great numbers in wheat-fields, busily engaged in devouring the plant-lice.

These minute insects have also their internal parasites, little ichneumons of the genus *Aphidius*. We have to go again to Dr. Fitch's article for information respecting their habits:

"On many of the wheat-heads, may at present (August 6) be noticed from one to a half dozen or more of these lice, which are very large, plump, and swollen, of the color of brown paper, standing in a posture so perfectly natural you suppose they are alive. Touch them with the point of a pin, you find they are dead. Pick off a part of their brittle skin; you see there is inside a white maggot doubled together like a ball. Put one or two of these wheat-heads in a vial, closing its mouth with a wad of cotton. In a week's time, or less, you find running lively about in the vial some little black flies, like small ants. These you see have come out from the dead lice, through a circular opening which has been cut in their backs. Drive one or two of these flies into another vial, and introduce to them a wheat-head having some fresh lice. See how the fly runs about them, examining them with its antennæ. Having found one adapted to its wants, watch how dexterously it curves its body forward under its breast, bringing the tip before its face, as if to take accurate aim with its sting. There, the aphis gives a shrug, the fly has pricked it with its sting, an egg has been lodged under its skin, from which will grow a maggot like that first seen inside the dead, swollen aphis. And thus the little fly runs busily around among the lice on the wheat-heads, stinging one after another, till it exhausts its stock of eggs, a hundred probably, or more, thus insuring the death of that number of these lice. And of its progeny, fifty it may be supposed, will be females, by which five thousand more will be destroyed. We thus see what efficient agents these parasites are in subduing the insects on which they prey. I find three different species of them now at work in our fields destroying this grain-aphis."

THE WHEAT-HEAD ARMY-WORM, *Albilinea* Huebner.—Injuring the heads of wheat, rye, and barley, beginning at the base, sometimes the center of the ear, sometimes hollowing out the soft grains, leaving nothing but the shell and the chaff; a caterpillar resembling the northern army-worm, but striped with sulphur-yellow and light and dark brown.

Though this is a common and wide-spread insect, ranging from Maine to Kansas and southward, it was not known to be injurious to crops until 1872, when it was found, according to Riley, seriously injuring oats in Pennsylvania. In 1874 and 1875 it was reported to injure wheat and timothy heads in Maryland and Pennsylvania. It was described as "hollowing out the soft grains and leaving nothing but the shell and the chaff," and "in some rye-fields the heads are almost void of grains and the ground literally covered with chaff, and that late-sowed rye would not be worth the harvesting were it not for the straw." It was more widely destructive in the Eastern States in 1875 than in 1874. June 14, 1876, Mr. J. W. Robson, of Dickinson County, Kansas, wrote Mr. Riley that for ten days past it had been noticed in the wheat. "The caterpillars begin their depredations at the base of the ear, and sometimes near the center of the ear. In one field that I examined to-day the caterpillars were abundant.

They were mostly at rest, reclining at full length on the straw, while only a few were feeding on the ears."

Larva.—The best marked worms are prettily striped with sulphur-yellow and straw-yellow, and with light and dark brown, as follows: A broad, dark-brown line along the back, divided along the middle by a fine white line generally obsolete behind; beneath this broad line on each side a straw-yellow line, half as wide; then a light-brown one of the same width as the last, and becoming yellow on the lower edge; then a narrower dark-brown one, containing the white spiracles; then a sulphur-yellow as wide as the third; then a less distinct light-brown subventral one, the venter being pale yellow. The head is large, straw-colored, and with two attenuating brown marks from the top to the lower face. The chrysalis is of the ordinary mahogany-brown color, and terminates in a stout horny point, with a corrugated base.

Adult.—The moth has the front wings straw-colored, with a pale line running along the middle to the outer third, and shaded with brown as follows: A shade beneath the white line, intensified at each end where it joins the white; another, along the posterior border, narrow at apex and broadening to the middle, where it projects along the middle of the wing above the white line, fading away toward base, and a fainter shade along the front or costal edge, intensifying toward apex. The species is one of the smallest of the genus, having but two-thirds of the size of the army-worm.—(Riley.)

THE WHEAT-THRIPS, *Limothrips tritici* Fitch.—"Upon the heads and stalks in June and July, exhausting the juices of the kernels and rendering them dwarfish and shriveled; exceedingly minute, active, long, and narrow six-legged insects, of a bright-yellow or of a shining-black color."—(Fitch.)

The wheat-thrips in this country also occurs on the onion, and is described more fully under the head of onion-insects. It represents the *Phlœothrips cenalium* of Europe, which does, at times, extensive injury to the wheat, gnawing and puncturing the seed, causing it to shrink and become what the farmers call "pungled." It also gnaws the young stalks just above the knots, causing the ear to become abortive. Another species common on wheat in New York, in June, is the Three-banded Thrips (*Coleothrips trifasciata*) of Fitch. It is nearly double the size of the wheat-thrips, being 0.07 inch in length, and is black; the dark wings having three broad white bands across them, while the antennæ arise close together, "and are composed of only five principal joints, of which the two first are short, and a third thicker than the others, which are long and cylindrical, the last one gradually tapering to a slender point, its apical portion being divided into small indistinct segments."

THE WHEAT-WORM, *Anguilluta tritici* Bauer.—Filling the cavities of a grain of wheat, a white fibrous substance, formed by gluten into balls of a silky nature, which instantly dissolve in water and exhibit hundreds of minute worms, causing the disease called "ear-cockle" or "purples."

Although this worm has not yet been observed in America so far as I am aware, it is not improbable that this disease occurs with us, though not yet detected. I abstract the following account, often word for word, from Curtis's "Farm Insects." Mr. Curtis took his description of the worm and its habits from Bauer's notes contained in Professor Henslow's "Report on the Diseases of Wheat."*

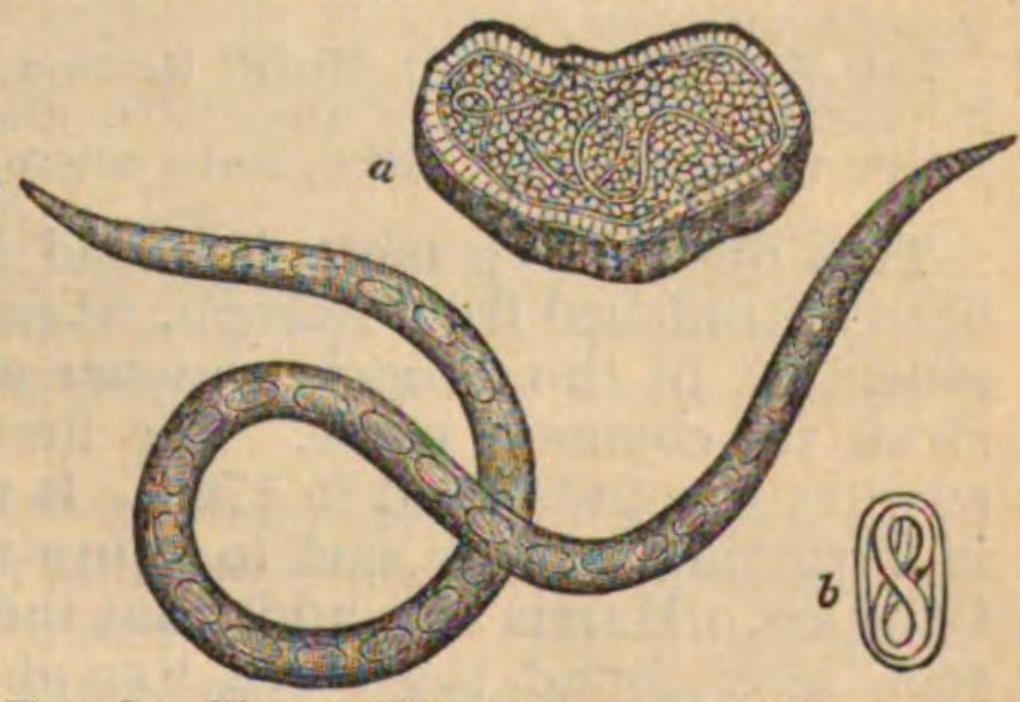


FIG. 8.—*Young Wheat-Worm, greatly magnified.* *a*, section of a grain exhibiting some worms and multitudes of eggs, magnified; *b* an egg containing a worm ready to hatch. (From Curtis, after Bauer.)

"The eggs are taken up by the sap from the infected grain which may have been planted, and hatch in the stalk as well as in the seed. The largest worms are ¼ inch long at least, of a yellowish-white color, and not so transparent as the young worms. Their heads are

* Journal of the Royal Agricultural Society, vol. ii, p. 19.

very distinct; they have a proboscis, which has three or four joints, which they contract or extend like an opera-glass. From the head, which is somewhat roundish, they taper gradually off toward the tail, which is scarcely half the diameter of the middle of their body, and ends in an obtuse, claw-like point. At a short distance from the end of the tail is an orifice surrounded by an elevated fleshy edge; from this orifice the worms discharge their eggs. The back of these old worms is nearly opaque, and appears jointed or annular; the number of joints or rings is from twenty-five to thirty. The belly-side is more transparent, and strings of ova can be distinctly seen through almost the whole length of the worm to the orifice by which the eggs are discharged." Those in the cavities of the mature grain are generally $\frac{1}{33}$ or $\frac{1}{36}$ inch long, milk-white, and semi-transparent. After laying all their eggs the parent worms soon die, and in a few days they decay and fall to pieces; but such is not the case at an earlier period of life, for after being dried, and appearing quite dead, on the application of moisture they become as lively as they were at first, and thus for five years and eight months Mr. Bauer was able to re-animate the worms by immersion, but it required a longer period as the time lengthened, and after that they died; other examples bred by him retained their reviviscent qualities for six years and one month. It seems probable that the glutinous substance in which they are enveloped preserves their vitality. They may be kept alive for three months in water.

"It appears from Mr. Bauer's investigations that the cavities of the grain are at first filled with a white fibrous substance, formed by gluten into balls of a silky nature. In water they instantly dissolve, and exhibit hundreds of minute worms, which become animated in less than a quarter of an hour when moistened, and the grains eventually assumed a dark-brown color, and were as hard as wood."

In some grains approaching maturity only one worm was found with the cluster of eggs, in others there were three (Fig. 8), the section of a grain exhibiting some worms and multitudes of eggs. The eggs come forth in strings of five or six together, and are detached in water; the young worms can then be seen through the transparent skin. (Fig. 8.) In about an hour and a half after the egg is laid in water the young worm begins to extricate itself, which it took one of them an hour and twelve minutes to accomplish.

INJURING STORED GRAIN.

THE ANGOUMOIS GRAIN-MOTH, *Gelechia cerealella* Linn. (Plate LXV, Figs. 7, 8.) Devouring the interior of the stored grains of wheat and corn, and transforming, within the grain, a soft, thick, fleshy caterpillar.

This destructive moth is found in granaries in this country, having been introduced from Europe, where it has been extremely destructive, especially in the French province of Angoumois, from which it has derived its common name. The first account of its occurrence in this country was published in 1768. It was then destructive to stored grain in Virginia, but was said to injure wheat forty years previous in North Carolina. Harris also adds that the French naturalist, Bosc, in 1796, or soon after, found this moth "so abundant in Carolina as to extinguish a candle when he entered his granary in the night." Harris further states that this grain-moth spread from North Carolina and Virginia into Kentucky and Southern Ohio and Indiana, "and probably more or less throughout the wheat region of the adjacent States, between the

thirty-sixth and fortieth degrees of north latitude," and it has been found even in New England. "Wheat, barley, oats, and Indian corn suffer alike from it, the last especially when kept unprotected more than six or eight months."—(Harris.)

The moth lays mostly in June and August, but probably at other times during the year, from sixty to ninety eggs in clusters of about twenty in a single grain of wheat or corn. In from four to six days the larvæ disperse, each selecting a single grain, burrowing in at the end whence the plumule grows out. The caterpillar, after eating out the inside of the grain of wheat or corn and exhausting its supply of food, sometimes eats its excrement once or even a second time. It transforms within the grain, spinning a silken web, and before pupating (*i. e.*, transforming to a pupa) gnaws a hole nearly through the shell for the exit of the moth. The larvæ of the first, or summer, brood mature in about three weeks, the moths appearing at harvest time. Those of the second brood hybernate in the grain, changing into moths the following summer.

Description.—The caterpillar (Plate LXV, Fig. 8, much enlarged) is unusually thick and plump, the skin being unusually thin and transparent. The moth (Plate LXV, Fig. 5) is ochreous with a dark-brown streak toward the base, and a few dark dots toward the end of the fore wings, while the hind wings are grayish-ochreous; sometimes the fore wings are unspotted. The wings are long and narrow, beautifully fringed, and expand about half an inch. Several chalcid parasites prey upon it.

Remedies.—Dry the grain in an oven or kiln with a heat of 167° Fahrenheit for twelve hours; fumigate in close vessels with charcoal-gas. Early thrashing and winnowing should be practiced, not later than the end of July. The grain should be stored in tight bins.

THE GRAIN-TINEA, *Tinea granella* Linn. (Plate LXV, Fig. 9.)—Devouring the interior of grains of wheat, tying several grains together, but transforming in cracks, etc., in the floor; a slender caterpillar.

This is also a European importation, and is more or less injurious to stored grain, though less so than the Angoumois moth. It is found flying in granaries in summer. The female lays from thirty to forty eggs, one or two in each grain. The caterpillar hatches in a few days and eats into the grain, closing the entrance with its castings, and after devouring the interior of one grain passes into others, uniting them with silk threads forming a web. When about to transform it deserts the grain, retires to cracks in the floor and constructs a cocoon, often by gnawing the wood and weaving the chips into its web until the cocoon has the form and size of a grain of wheat. In this it hibernates, changing to a pupa in the spring, and in two or three weeks appearing as a moth.

Description.—The larva is cylindrical, with long, fine, scattered hairs, and of a light-buff color, with a reddish head. It is about four or five tenths of an inch in length. The moth differs entirely from the Angoumois moth in form, and is creamy-white, with six brown spots on the costa of the fore wings, and with dark hind wings. The wings expand 0.06 inch.

Remedies.—Besides those suggested for the attacks of the preceding grain-moth, the granary when empty should be thoroughly cleansed and whitewashed, or washed with coal-oil, and when the caterpillars are at work the grain should be often and thoroughly stirred about.

THE GRAIN-WEEVIL, *Sitophilus granarius* (Linn.). (Plate LXV, Fig. 10 *e.*)—A short, maggot-like grub, eating the interior of the grain and transforming into a minute reddish weevil, which also injures stored grain.

While the wheat-fly and several other insects are dubbed "weevils"

by the ignorant, the present insect and the rice-weevil are the only ones found injuring wheat, and then only when stored. I copy the following account of this common weevil from Harris, knowing nothing personally of the insect: "This little insect, both in the beetle and grub states, devours stored wheat and other grains, and often commits much havoc in granaries and brew-houses. Its powers of multiplication are very great, for it is stated that a single pair of these destroyers may produce above six thousand descendants in one year. The female deposits her eggs upon the wheat after it is housed, and the young grubs hatched therefrom immediately burrow in the wheat, each individual occupying alone a single grain, the substance of which it devours, so as often to leave nothing but the hull; and this destruction goes on within while no external appearance leads to its discovery, and the loss of weight is the only evidence of the mischief that has been done to the grain. In due time the grubs undergo their transformations, and come out of the hulls, in the beetle state, to lay their eggs for another brood.

Grub and beetle.—The grub is short, thick, fleshy, maggot-like; while the weevil is "a slender beetle of a pitchy-red color, about one-eighth of an inch long, with a slender snout slightly bent downward; a coarsely-punctured and very long thorax, constituting almost one-half the length of the whole body, and wing-covers that are furrowed and do not entirely cover the tip of the abdomen."

Remedies.—These insects are effectually destroyed by kiln-drying the wheat; and grain that is kept cool, well ventilated, and is frequently moved, is said to be exempt from attack.—(Harris.)

The rice-weevil, *Sitophilus oryzæ* Linn. (Plate LXV, Fig. 10 *a*, *b*, *c*), attacks stored rice, and also grain and corn. It differs from the *S. granarius* in having two large red spots on each wing-cover, and in being a little smaller, as it measures only a line in length, exclusive of the snout. It is abundant in the Southern States, where it is called the "black weevil." In the South it is said, according to Harris, to lay its eggs on the rice in the fields; but this statement needs confirmation. "The parent beetle bores a hole into the grain, and drops therein a single egg, going from one grain to another till all her eggs are laid; she then dies, leaving, however, the rice well seeded for a future harvest of weevil-grubs. In due time the eggs are hatched, the grubs live securely and unseen in the center of the rice, devouring a considerable portion of its substance, and when fully grown they gnaw a little hole through the end of the grain, artfully stopping it up again with particles of rice-flour, and then change to pupæ. This usually occurs during the winter; and in the following spring the insects are transformed to beetles, and come out of the grain. By winnowing and sifting the rice the beetles can be separated, and then should be gathered immediately and destroyed." (Harris.) Besides these insects of the granary Dr. Fitch describes the *Agromyza tritici*, which sometimes occurs in great numbers in stored wheat in New York.

THE GRAIN SYLVANUS, *Silvanus surinamensis* (Linn.).—A small brown beetle gnawing the ends of rye, oat, and wheat grains.

This is a very common and annoying little beetle, which in Europe is known to be a great pest in stores and warehouses. In Pennsylvania, it has been found to injure stored rye, wheat, and oats, eating holes in the grain. It is a little flat, brown beetle, not quite a line in length, characterized chiefly by the last three joints of the antennæ being enlarged, and by having three prominent longitudinal ridges on the thorax, which is armed on the sides with six teeth.

Remedies.—"The best way to get rid of it, when the grain cannot be

subjected to a killing heat, is to stack the grain a year or two until the insects are starved out of the barns, just as they lay by ships in the grain-trade, or use them for other freight when they once become infested with this insect, or with the true grain-weevil."—(Riley.)

AFFECTING INDIAN CORN.—INJURING THE ROOTS.

CUT-WORMS, *Agrotis suffusa* (Denis and Schiefermüller) and other species. (Plate LXV, Figs. 2, 3, 4, 5.) Eating the roots of corn and other cereals; large, dark, obscurely-colored, smooth-bodied caterpillars, hiding by day and feeding by night.

Not only Indian corn but other cereals and grasses are indiscriminately attacked by different species of caterpillars called cut-worms from their habit of cutting off young, succulent plants as they are coming up out of the ground. They are thick, with a distinct horny prothoracic plate, and are usually marked with shining and warty, or smooth, spots of the same general color as the rest of the body; they are usually striped longitudinally. They are seen early in spring hiding under sticks and stones, having hibernated in this state. They feed by night, hiding in the day-time. The chrysalids are situated under ground. They transform to moths, sometimes call dart-moths, which might be known by their crested trunks and ciliated or pectinated antennæ, while the fore wings are rather narrow, usually with a dark dot near the middle of the wing, and just beyond a reniform marking, while there is usually a basal, median, black streak. The moths appear in midsummer, and lay their eggs near the roots of grasses, which hatch in the autumn, the worms living on roots and sprouts of herbaceous plants. "On the approach of winter they descend deeper into the ground, and, curling themselves up, remain in a torpid state until the following spring, when they ascend toward the surface, and renew their devastations."—(Harris.)

Our largest species, *Agrotis suffusa* (Plate LXV, Fig. 2), was probably imported from Europe. The caterpillar is described as follows by Riley:

Its general color above is dull, dark, leaden-brown, with a faint trace of a dirty yellow-white line along the back. The subdorsal line is more distinct, and between it and the stigmata are two other indistinct pale lines. There are eight black, shiny, piliferous spots on each segment, two near the subdorsal line, the smaller a little above anteriorly; the larger just below it, and a little back of the middle of the segment, with the line appearing especially light above it. The other two are placed each side of the stigmata, the one anteriorly a little above, the other just behind, in the same line with them, and having a white shade above it.

Another cut-worm, which is still more abundant in the Middle and New England States, is the young of the Clandestine moth (*Noctua clandestina* of Harris), and may be called the Corn cut moth. While the fully-grown caterpiller has not been described, the young are said by Harris to be "more or less distinctly marked above with pale and dark stripes, and are uniformly paler below." According to Melsheimer, as quoted by Harris, when first hatched, it feeds on the various grasses, descending, when half-grown, in the ground on the approach of severe frosts, and re-appearing in the spring, and then beginning to grow again, attaining their full size and pupating before the middle of July, often much earlier, as in the New England States the moth is seen from the middle of June to the middle or end of August.

Moth.—It is of a peculiar dull-blackish, with the body very flat when the wings are expanded, and with obscure markings. "The fore wings are generally of a dark ash-color, with only a very faint trace of the double transverse wavy bands that are found in most species of *Agrotis;* the two ordinary spots are small and narrow, the anterior spot being oblong oval, and connected with the oblique kidney-shaped spot by a longitudinal black line." The hind wings are rather dark, and the head and legs darker than usual, almost blackish. It expands an inch and three-quarters.

Remedies.—Among the more general preventive remedies, suggested by Harris, are the soaking of corn, before planting, in copperas-water, and mixing salt with the manure, though these are of less use than plowing deep in the autumn so as to turn up the half-grown worms, so as to expose them to winter colds and insectivorous birds. When the worms have begun their attacks, hand-picking, *i. e.*, digging up the worms which hide by day in the soil around the plant, is, of course, the most efficacious remedy. An excellent plan is to make a deep hole, with a stake, in the hills, down which trap the caterpillar is liable to fall.

WIRE-WORMS.—Eating the roots of corn and wheat, hard cylindrical, round, reddish worms, tapering toward the head and tail, and changing into snapping-beetles.

The roots of corn, wheat, and grasses are often injured to a lamentable extent by wire-worms, the larvæ of various species of snapping-beetles belonging to the family *Elateridæ*.

THE CORN-MAGGOT, *Anthomyia zeæ* Riley.—Gnawing seed-corn after it is planted; a maggot like the onion-worm.

This maggot has been found to injure seed-corn just after being planted, and to abound to such an extent as to nearly ruin whole corn-fields, as it gnaws into the corn, finally causing it to rot. When fully fed they contract, forming a barrel-shaped brown case (Fig. 8, *b*), within which lies the pupa, and in a week after the flies appear. As a remedy, soak the corn before planting in gas-tar or copperas-water.

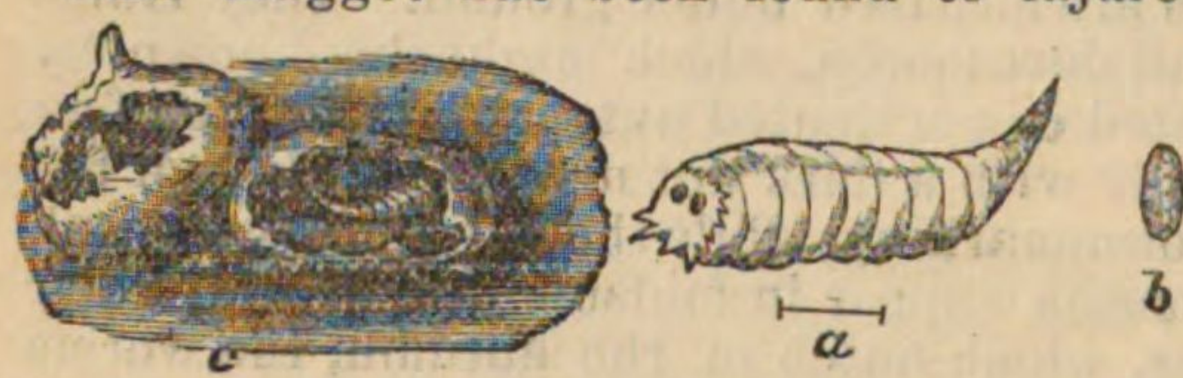


Fig. 9.—*Corn-Maggot.* *a*, larva, enlarged; *b*, pupa-case; *c*, corn injured by worms, natural size.

Larva.—Closely resembling the maggot of the onion-fly; yellowish-white; blunt at the posterior end and pointed in front. It is about a quarter of an inch in length.

Fly.—Head tawny in front, with a brownish edge; antennæ black; face and orbits brownish-white; thorax and abdomen pale yellow-brownish ash-colored; thorax with an indistinct middle stripe of brown; legs black. Length one-fifth of an inch.—(Riley.)

THE CORN-WEEVIL, *Sphenophorus zeæ.*—Puncturing large holes in young corn near the base of the stalk, before it has spindled, and sometimes destroying whole fields of young corn.

In the Practical Entomologist (vol. ii, p. 117, 1867) the late Mr. Walsh described this weevil, and gave an account of its ravages in the Middle and Western States. Mr. Robert Howell, in Tioga County, New York, was among the first to detect it, and under date of June 14, 1869, he writes me that "this is the fourth year they have infested the newly-planted corn in this vicinity. The inclosed specimens were taken on the 11th instant. I presume they have been in every hill of corn in my field. They pierce the young corn in numerous places, so that each blade has from one to six or eight holes the size of a pin or larger, and I found a number last Friday about an inch under ground, hanging to young stalks with much tenacity. When very numerous, every stalk is killed. Some fields, two or three years ago, were wholly destroyed by this insect." I have detected this insect at Hyannis, Mass., June 25.

It is a rather large black weevil, with a long, narrow, subcylindrical body, and with coarse gray punctures. The head is black, finely punctured, with still more minute punctures on the beak. At the base of the beak just between the eyes is a small oval pit. The beak is nearly one-third as long as the body; it is curved downward, slightly compressed, with the tip seen from above dilated slightly and triangular.

On the prothorax is a long, lozenge-shaped, smooth black median area, with two smooth spots on the side near the front; these, with two longer diverging spots behind, form an inverted Y on each side of the body. Behind are coarse gray punctures. The wing-covers are marked with rows of coarse punctures along the striæ, much larger than those on the thorax. On the smooth spaces between the striæ is a row of more or less crowded minute punctures. On the base of the elytra, near the outer edge, is a low smooth tubercle, and a larger one near the tip. On the extreme tip of the abdomen, near the elytra, are two short diverging rows of fine stiff tawny hairs, which stand out straight from the end. The legs are black, the tarsi reddish, piceous. Beneath, the body is black and widely punctured. It measures 0.40 of an inch in length.

Remedies.—Until we know more of its habits, its mode of life in the larva stage, and its native food-plant, we are at a loss to suggest remedies against the attacks of this insect. When the corn is observed to be suffering from their punctures, they should be picked off with the hand, and the young blades of corn carefully watched. These weevils are so large as to be readily detected after a little practice.

THE SPINDLE-WORM, *Achatodes zeæ* (Harris).—Boring in the stalk before the corn-spindles, causing the leaves to wither, a caterpillar an inch long, smooth and naked, with the head and last segment black.

The ravages of this worm generally begin, says Harris, "while the corn-stalk is young, and before the spindle rises much above the tuft of leaves in which it is embosomed. The mischief is discovered by the withering of the leaves, and, when these are taken hold of, they may often be drawn out with the included spindle. On examining the corn, a small hole may be seen in the side of the leafy stalk, near the ground, penetrating into the soft center of the stalk, which, when cut open, will be found to be perforated, both upward and downward, by a slender worm-like caterpillar, whose excrementitious castings surround the orifice of the hole." It also bores into the stalks of the dahlia and of the elder. The brown chrysalis is rather slender, and is found within the burrow made by the caterpillar.

Larva.—Smooth and apparently naked, yellowish, with the head, the top of the first and of the last wings black, and with a double row, across each of the other rings, of small, smooth, slightly elevated, shining black dots.

Moth.—The fore wings rust-red; they are mottled with gray, almost in bands, uniting with the ordinary spots, which are also gray and indistinct; there is an irregular tawny spot near the tip, and on the veins there are a few black dots. The hind wings are yellowish-gray, with a central dusky spot, behind which are two faint, dusky bands. The head and thorax are rust-red, with an elevated tawny tuft on each. The abdomen is pale brown, with a row of tawny tufts on the back. The wings expand nearly an inch and a half.—(Harris.)

Remedies.—The obvious remedy is, when the leaves are seen to wither, to cut open the stalk, and, on finding the worm, pull all the infested plants.

THE STALK-BORER, *Gortyna nitella* Guenée (Plate LXV, Fig. 6), moth and caterpillar Boring in the stalks of corn, potato, tomato, etc., a caterpillar of a pale, livid hue, with light stripes along the body; also sometimes boring into the cob of growing Indian corn.

This borer not only infests corn and potatoes, but also the tomato and the dahlia, aster, etc., according to Riley. The worm is not found in the Western States earlier than June and July, and the moths appear late in August and early in September. The insect is probably single-

brooded. "The young worm hatches about the 1st of July and immediately commences its work of destruction. It works in such a surreptitious manner as to be too often unnoticed till the vine is destroyed. The plant does not generally show any signs of decay until the cocoon is about fully grown, when it wilts and is past recovery. This occurs about a month after the worm is hatched, and it then crawls just under the surface of the ground, fastens a little earth together around itself by a slight net, and changes to a chrysalis of a very light mahogany-brown color, and three-fourths of an inch long. The moth comes forth the fore part of September. The careful culturist need fear nothing from this troublesome insect, as an occasional close inspection of the plants about the 1st of July will reveal the hole where the borer has entered, which is generally quite a distance from the ground, and by splitting downward one side of the stalk with a penknife it may be found and killed. If this inspection be made at the proper time the worm will be found but a short distance from the hole, and the split in the stalk will heal by being kept closed with a piece of thread."—(Riley.)

Description of the larva.—Of a livid hue when young, with light stripes along the body; when full grown, it generally becomes lighter, with the longitudinal lines broader.

Moth.—Of a mouse-gray color, with the fore-wings finely sprinkled with Naples-yellow, and having a very faint lilac-colored hue; but distinguished mainly by an arcuated pale line running across their outer third.—(Riley.)

Besides the chinch-bug, and also other insects already noticed among those preying on wheat, the leaves of corn are infested by the young of the large Io moth and by the *Arctia arge*.

The cotton-boll worm (*Heliothis armigera*) sometimes attacks corn in the ear, eating the silk, and afterward devouring the terminal kernels, hiding within the husk. Whole fields of corn have been thus injured in Kentucky, but it is most destructive in Southern Illinois, where there are two broods of the worm, the early and late corn faring the worst.

INJURING THE ROOTS AND LEAVES OF GRASS.

Besides most of the insects previously mentioned, which injure the roots and stalks of cereals, the grass on lawns is often killed in patches by the white grub or larva of the June beetle (*Lachnosterna fusca*, Fig. 10). So effectually are the roots eaten that the sod can be rolled up like a carpet. The white grub is injurious on lawns in Illinois, as well as in the New England States. Wire-worms, the larva of the various species of *Neonympha*, cut-worms, the larvæ of crane-flies (*Tipula*), and of the salt-marsh caterpillars (*Leucarctia acræa*), and very homopterous insects, such as the spittle insects, especially *Ptyches lineatus*, (Fig. 11), are dependent for their livelihood on grasses. The latter is a very abun-

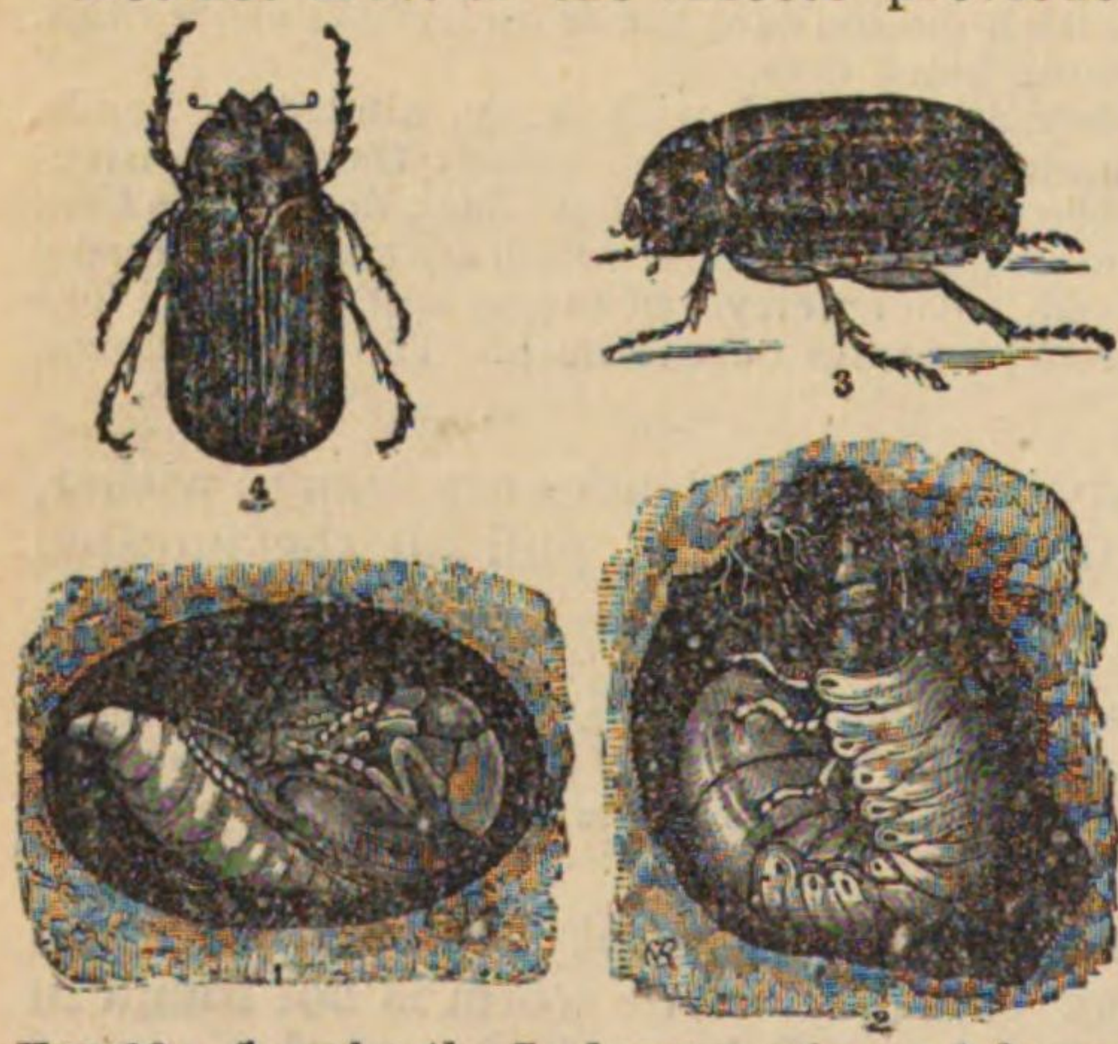


FIG. 10.—June beetle, *Lachnosterna fusca*. 1, larva; 2, pupa; 3, 4, adult.

dant insect in early summer, living in the center of a mass of frost on the leaves of grass. The larva is to be found concealed in a mass of frost late in May and early in June; the adult is exceedingly abundant late in summer.

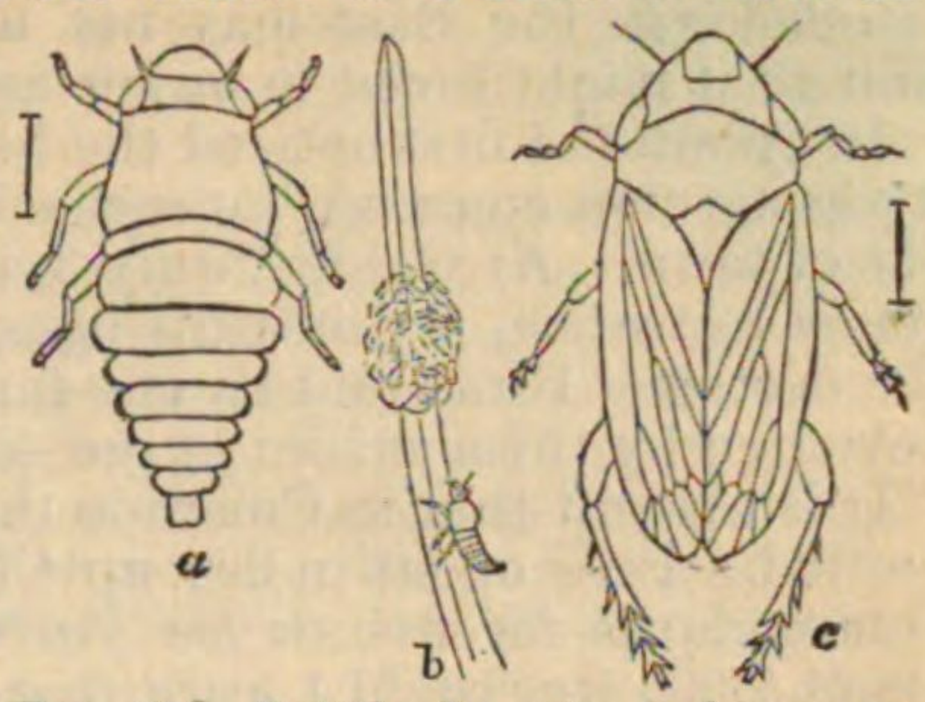


FIG. 11.—Spittle Insect. *a*, larva, enlarged; *b*, natural size of larva; *c*, adult, enlarged.

Clover is attacked by various insects, especially the larva of *Drasteria erechtia*, a moth very abundant in May, and again in August and September, in grass-lands. The seeds are sometimes inhabited by minute weevils, while clover, when stacked or even housed, is sometimes injured by the "clover-worm," the larva of *Asopia costalis*, a dull, whitish worm, changing to a lilac-colored moth ornamented with golden lines and fringes.

THE COLORADO POTATO-BEETLE, *Leptinotarsa decemlineata* of Gemminger and Harold, *Doryphora 10-lineata* Say.—Devouring the leaves, sometimes the tubers, a large, thick-bodied, reddish-orange grub, spotted on the sides with black, changing under ground into a large hemispherical yellow beetle about half an inch long, with ten wide black stripes on the back; three broods of the worm appearing in one season.

Its original habitat.—This beetle was originally described by Mr. Say in 1824, having been found by him the year previous, when he remarked, "This species seems to be not uncommon on the Upper Missouri, where it was obtained by Mr. Nuttall and by myself. The variety (white with two of the lines united, probably the species *juncta*) I found on the Arkansas." (Journal Academy of Natural Sciences Philadelphia, vol. iii, 1824.) This would indicate that its native habitat was the plains of Dakota, Western Nebraska and Kansas, Colorado, and perhaps the western portion of Indian Territory and Texas. Dr. G. H. Horn, the well-known coleopterist, writes me as follows: "West of the Mississippi I have it from Texas. I have never seen it from Mexico nor west of the Rocky Mountains. If it goes west, I believe it will be through New Mexico and Arizona, and not over the Rocky Mountains."

Lieutenant Carpenter, U. S. A., writes me: "I have never seen the Colorado potato-beetle north of the North Platte as far west as Fort Laramie, Fort Fetterman, and Big Horn Mountains." Probably co-extensive with the original distribution of the Colorado potato-beetle, is that of its original food-plant, concerning which Mr. Sereno Watson, the botanist of the United States Geological Survey of the one hundredth parallel, thus writes me: "The *Solanum rostratum* ranges from Texas and New Mexico to the Upper Missouri eastward of the mountains. I have no evidence of its being found at all west of the Rocky Mountains, and, indeed, the order appears to be almost wholly wanting throughout the entire Great Basin."

In Colorado, in 1875, I first met with this beetle at Lawrence, Kans., when Professor Snow told me it was chiefly confined to the *Solanum rostratum*, a road-side weed, which is now very abundant in Kansas and draws off the beetle from the potato, which consequently suffers comparatively little from its attacks in that State.

Professor Snow further writes me that for five or six years past, since taking up his residence in Kansas, "it has never done any damage worth mentioning, always preferring its original food-plant (which abounds here as a roadside weed) to the potato. I did not see it in Manitou, Colo., this summer (1876).

The question arises whether the cultivation of this weed around potato-fields in the East may not be a means of relief from its attacks, though it might breed in larger numbers, if that were possible.

In Colorado I first noticed the beetle in the vicinity of Denver, where it was not then common, but earlier in the season had ravaged potato-fields out of town. At Golden, July 3, it was observed in abundance on *Solanum rostratum*, not only the eggs but the larvæ in all stages as well as the beetles. I was told by one farmer that he had two rows of potatoes devoured by them earlier in the season.

It is evident that in Colorado the injury to the potato will always be limited. Five or six miles up Clear Creek Cañon it has injured the potato-plants for five or six years, but nowhere above an altitude of about 7,000 feet could I learn that it occurred, and it seems indigenous only to the plains, and the cañons among the foot-hills. None were to be seen in Utah.

Mr. T. Martin Trippe writes me that it destroyed potato-plants early in the season in Howardsville, Southern Colorado.

Its journey from the plains east of the Rocky Mountains to the Atlantic.—The history of the successive invasion of the prairies of the Mississippi Valley and of the wooded district of the Middle and Northeastern States, until only the ocean proved a sufficient barrier to their advances, is a subject of a good deal of interest to the naturalist, whatever may be thought of the dismay with which eastern farmers have looked upon its arrival. Some years ago it was confidently announced that the Colorado beetle would not flourish in the damp, cold climate of New England; that the summers were so wet that it would die while lying as a pupa under ground. But at the present time of writing, September 15, 1876, it is doing perhaps as much damage in the Northeastern States as in the Western, and the newspapers report that it has crossed the Atlantic and effected a landing in Bremen, Germany, and there is no reason why it should not overrun Europe after successfully withstanding the great differences in climate between the eastern and western regions of the United States. This insect, so indifferent to ordinary climatic differences, may be compared to a weed which, introduced in a new country, overruns and displaces the native vegetation. Like weeds, the Colorado potato-beetle, with a number of other widely-destructive insects, may be regarded as *prepotent* animals.

Fortunately for the historian of the movements of this insect, the late Mr. B. D. Walsh, at an early date after it began to spread eastward from the plains of Colorado, published in the Practical Entomologist, vol. i, No. 1, October, 1865, an account of its travels. In 1859 it had in its journey eastward reached a point 100 miles west of Omaha, Nebr. It appeared in Kansas and Iowa in 1861. It entered Southwestern Wisconsin in 1862. In 1864 and 1865 it crossed the Mississippi River, entering Illinois from the eastern borders of North Missouri and from Iowa "upon at least five different points on a line of 200 miles." Thence it has traveled eastward at the rate of a little over 70 miles a year. In 1867 it had appeared in Western Indiana and Southwestern Michigan, and in 1868 had generally overspread Indiana and appeared in Ohio. From the statements of Mr. Riley, it appears that this insect entered Canada in July, 1870, and swarmed in 1871 between the Saint Clair and Niagara Rivers. The same year Dr. Trimble reported its presence in Pennsylvania, and in 1871 it also was seen in New York. A southern column advanced eastward into Kentucky, arriving there probably in 1869. In 1872 it had reached Lancaster County, Pennsylvania, and Cattaraugus County, New York; and in 1873, according to Mr. Riley, it had pushed

to the "extreme eastern limit" of that State. It was reported in the same year to have been seen in the District of Columbia, according to the Monthly Report of the Department of Agriculture for August and September, 1873.

During the summer of 1876 it was observed by Prof. H. W. Parker in great abundance at Long Branch, being thrown up in windrows on the beach. The two following extracts from the daily papers also show how abundant it has been on Long Island and in Connecticut:

It is said that the potato-bugs on Long Island are very numerous and have already made sad havoc with the early crops. Mr. Jacob Schoemaker, a farmer at Flatbush, has had about $2,000 worth of early sprouts destroyed, and the farmers in that section, in plowing up their grounds, discovered bushels of the bugs.—(Forest and Stream, April 27, 1876.)

Colorado potato-bugs have been washed ashore at Milestone and other places in Connecticut in such numbers of late as to poison the air. The captain of a New London vessel says that they came on board in such swarms while at sea that they had to close the hatches.

In 1874 it became well established in Connecticut, New Jersey, New York,* Pennsylvania, Delaware, Maryland, and Virginia. (Riley's Seventh Report.) In the summer of 1874 it appeared at Williamstown, Mass., in small numbers, as I am told by Mr. J. S. Kingsley. In 1875 they were commonly seen, especially on the railroad-track, before July 9.

Concerning its habits in Connecticut, Mr. J. H. Pillsbury writes me as follows from Middlebury, September 26, 1876:

I took from the sides of a glass jar, in which I had confined a number of beetles of *Doryphora decemlineata*, a few eggs, which had been laid May 30, and placed them in circumstances for hatching them. The eggs hatched June 6, and the larvæ were placed upon fresh leaves of the potato. They immediately commenced eating, and continued almost without ceasing during the day, until June 22, when all but one entered the earth that had been provided for them to pupali in. The remaining larva entered the earth the next day.

Two of the beetles appeared July 1, and more the next day. Upon examining the earth I found one pupa with the wings only slightly developed, and this one did not mature. As soon as the beetles were out they were fed with potato-leaves, and resumed their eating as if determined to make up lost time. The first eggs laid by these beetles were found July 7. The whole time, therefore, from the one brood of eggs to another is only thirty-eight days, twenty-two of which were spent in actively devouring the plant on which it feeds. If we suppose the female to continue to deposit her eggs for forty days, as Professor Packard states, sixty-two days of the seventy-eight which the insect lives are spent in vigorous destruction of its favorite plant, the potato. These observations also indicate the probability of three broods from the earliest of each season before the middle of September, up to which time the insect has been found on the potato in our section.

J. H. PILLSBURY.

MIDDLETOWN, CONN., *September* 26, 1876.

Its first appearance in the center of the State was in Belchertown, where, I am informed by Mr. L. W. Goodell, "a single larva was found July 15, and was apparently the last one of a brood, as several hills of potatoes near were entirely denuded of foliage, and I could find no others nor signs of any in that or other fields of potatoes in the vicinity, although I searched carefully. The one taken was placed in a box of earth and immediately buried itself, and was transformed to a beetle eleven days thereafter. About this time I found and killed some fifty of the beetles on the same potato-patch, which were probably a part of the same brood. No more of the larvæ were seen for about three weeks, when they made their appearance in large numbers in several fields." When I visited these fields during the last of September, thousands of the larvæ, in different stages of growth, were to be seen on the vines.

* At Norwich, N. Y., Mr. J. S. Kingsley first found the larvæ in July, 1874, and they were much more abundant the year following. He found them in abundance in 1875, in Binghamton and Owego.

The next year, 1876, in Essex County, Massachusetts, they attracted the attention of farmers and others about the 1st of June. Specimens brought me from Marblehead and Lawrence laid eggs June 7, which hatched June 12. June 22, I found the beetle and young in all stages, from the egg up to the nearly mature larva, in a garden in Salem, and a few days after heard of its appearance in the towns of Reading, Beverly, Wenham, Hamilton, and Essex. In 1876 it was extremely injurious in Essex County. I am informed by Mr. John H. Sears, of Danvers, that half his crop of late potatoes were devoured by this beetle, and he thinks that there was a proportionate loss throughout the county. Early potatoes mostly escaped their ravages. The potato-fields in the neighborhood of Amherst were overrun with them soon after the plants came up, and in September I saw the beetle everywhere. In 1877 the yield of potatoes will be undoubtedly very light and potatoes high priced. During the autumn of 1876 they were said to be unusually high.

At the same time I learned from Mr. Isaac L. Ham, of Winchendon, Mass., a town about 18 miles west of Boston, that eggs and beetles were found on the vines the 20th of July, 1875. Beetles were seen at Lowell in August, 1875. It appears from these facts that the beetles must have been introduced along lines of railway in different portions of Massachusetts in 1874.

In 1875 it appeared in the western part of Vermont, and during the summer of 1876 has been reported as more or less abundant in various parts of the State. In 1875 it appeared for the first time in New Hampshire, according to C. H. Fernald. In 1866 Mr. Walsh predicted that it would reach Maine "in ten or twelve years." His prediction has proved to be a true one. In Maine, according to Prof. C. H. Fernald, it was first seen in 1875, and occurred not, so far as I can learn, on the southwestern border of the State, but in the central portion, and this leads me to think that its appearance here, as well as in New England generally, has been accelerated by its transportation on freight-cars which have been sent through from different points in the West. It is a well-determined fact that the diffusion of noxious insects over the United States is greatly promoted by railways and "through" freight-cars, as permanent tracks are thus made through forests and across rivers, the natural barriers of insect life.

Regarding its advent in Maine, I will first quote from a letter of Prof. C. H. Fernald, of the Maine State Agricultural College, dated Orono, August 23, 1876:

> The true Colorado potato-beetle is really in this State, but has not yet arrived so far east as this place. It has been reported at Orrington, near Bucksport, but I think it more than likely to have been the three-lined potato-beetle, (*Lema trilineata*). Specimens were sent me from Winterport which proved to be the three-lined. The *true* beetle (imago) was sent to me about three weeks ago from Skowhegan, where it was common enough to attract attention. One of our students found it in Saco in July of this year. A few days ago I had a letter from a friend in Wilton, who says they are common there. Last fall I looked into the matter a little, and could not learn that they had at that time reached the western boundary of Maine, though they were in New Hampshire. Reasoning from their rate of progress across the continent, I concluded they would travel this year as far as the Kennebec River, which they seem to have done. I suppose they have come into the State by their own means of distribution—flying from field to field.

Mr. D. A. Conant, in a communication to the Maine Farmer, dated July 28, states that certain beetles, identified by the editor of that paper (Mr. S. L. Boardman) as *Doryphora* 10-*lineata*, occurred in Temple, Me., near West Farmington. Mr. R. A. Davis writes to the same paper August 6, from South Norridgewock, as follows:

> We had very dry and hot weather in July; crops suffered very much. Two weeks ago to-day we had a nice rain, with heavy showers, and since that corn and potatoes

look quite well. Grasshoppers have taken all the grain about here, and they are very thick now. The caterpillars took all the leaves from the orchards, consequently there are no apples to speak of; and now the Colorado potato-bug is here, or what we call the same as has been making such havoc in the West for several years past. I send one to you to-day in a box. I hope you will be able to inform us if this is the genuine potato-beetle. [It is the genuine Colorado beetle.—ED.] They first made their appearance in this town on a small piece of potatoes belonging to Herbert E. Hale, near where H. C. Hall & Co. have unloaded considerable corn that came direct from the West, and it is supposed that they might have been brought here in that way. They have also made their appearance on Ed. Farnham's potatoes on the old Whiting farm at Larone. The one I send you I took from the potato-vines in John W. Bates's garden in this town. They have not done much damage here as yet, for they have been pretty thoroughly picked.

Early in October specimens were found on potato-tops in North Dixmont, Me.—(Maine Farmer.)

None have yet been reported from New Brunswick or Nova Scotia.

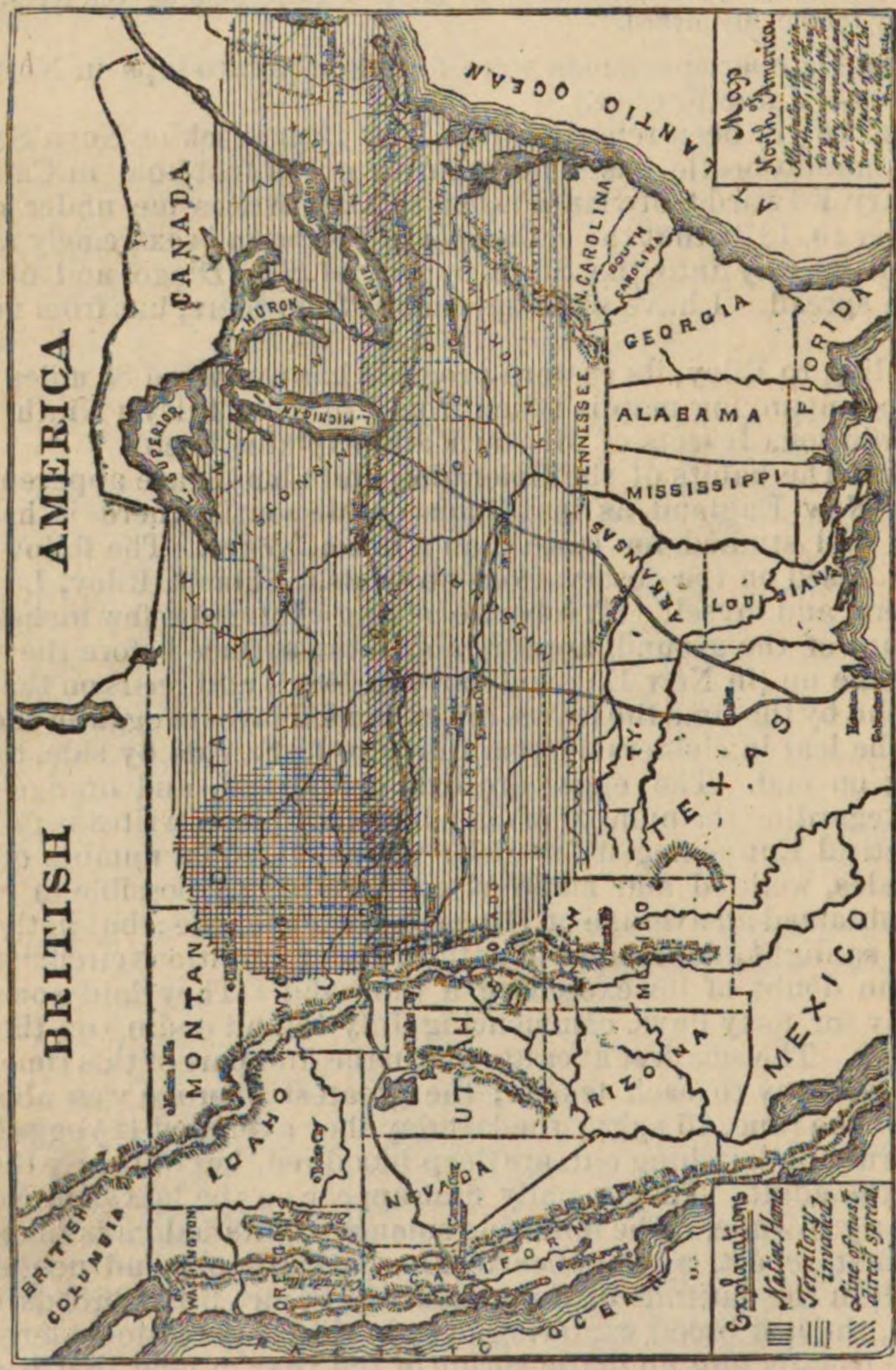
The Colorado beetle has unfortunately got a foot-hold in California. Mr. Henry Edwards, of San Francisco, Cal., writes me under date of September 10, 1876, that the "*Doryphora* 10-*lineata* is extremely rare. It has found its way into the State by way of San Diego and of course will soon spread. I have some specimens from there, but from no other locality."

According to Riley, its eastern progress has averaged 88 miles a year.

The accompanying map is taken from Professor Riley's Ninth Report on the Injurious Insects of Missouri, and explains itself.

Habits.—The habits of the Colorado potato-beetle are apparently the same in New England as in Illinois or Missouri, where it has been watched and studied for more than a dozen years. The following account is based on the observations of Walsh, Shimer, Riley, Le Bauer, and others, and myself. The beetle having wintered a few inches under the surface of the ground, appears above the surface before the potato-plants come up (in New England early in May), and feeds on the young shoots, and by the time the leaves are expanded lays its eggs on the under side of the leaf in clusters of from thirty to forty, side by side, the eggs standing on end. The eggs are oval-cylindrical, and orange-red in color. Regarding the number of eggs laid, Dr. Shimer writes as follows in the Practical Entomologist for 1866: "From an equal number of males and females, well-fed and made as comfortable as possible in confinement, I obtained an average of 719 eggs to each female; but in the fresh pure air, sunlight and freedom of nature, under propitious circumstances, I have no doubt of its exceeding a thousand. They laid some eggs every day for forty days, commencing July 15 and ending on the 1st of September. The smallest average was in the first part of this time, being 7½ eggs per day to each female; the greatest average was about the middle of the time, 75 eggs; the last day they averaged 12½ eggs." The young grub, on hatching out, are deep blood-red, but of nearly the same form as the adult. They usually first appear on the leaves in New England early in June. The following summary of its habits is taken from Riley's first report, and applies to Missouri, Illinois, and neighboring States: "In the latitude of Saint Louis there are three broods during the year, the last brood wintering over in the beetle state underground. They are usually dug up in the spring of the year in land that had been planted to potatoes the year before. The beetles issue of their own accord from the ground about the 1st of May, and the last brood of beetles enters the ground to hibernate during the month of October. Though in general terms this beetle may be said to be three-brooded, yet it may be found at almost any time of the year in all its different stages. This is owing to the fact that the female continues to deposit

her eggs in patches from time to time, covering a period of about forty days; and also from the fact that among, those larvæ, which all hatch out in one day, some will develop and become beetles in a week and even ten days earlier than others. Thus it may be that some of the late individuals of the third brood pass the winter in the pupa state, though the normal habit is to transform to beetles. Each female is capable of depositing upward of a thousand eggs before she becomes barren, and in from thirty to forty days from the time they were deposited they will have produced perfect beetles. These beetles are again capable of de-



Map showing spread of Colorado potato-beetle.

positing eggs in about two weeks after issuing from the ground, and thus in about fifty days after the egg is laid the offspring begins to propagate. The pupa of the Colorado potato-beetle is represented at Fig.—. It is formed in a little cavity which the larva had made perfectly smooth and hard, and it is of the same color as the larva. The beetle on first emerging from it is quite pale and soft, without any markings whatever."

Although no species of this family are known to be poisonous, yet it is probably true, from the facts adduced by Riley and others, that the fumes arising from the bodies of a large number of them when killed by hot water produces sickness. This is due, perhaps, to a volatile poison thrown off from their body immediately after death; but since fowl feed upon them to a large extent, and as no one has been known to have been poisoned, at least severely, in handling them, there is no reason why hand-picking should not be resorted to.

Enemies of the Colorado potato-beetle.—Besides a number of bugs and beetles which devour this beetle, a species of *Lydella* (*L. doryphoræ* Riley, Fig. 12) is very destructive to it. Mr. Riley says, "this fly destroyed fully 10 per cent. of the second brood and 50 per cent. of the third brood of potato-beetles that were in my garden. It bears a very close resemblance, both in color and size, to the common house-fly, but is readily distinguished from the latter by its extremely brilliant silver-white face." No ichneumon parasite has yet been found preying upon it. In the Western States turkeys, hens, and chickens, and other birds destroy numbers of the grubs and beetles, and render most efficient aid. J. W. Perry, esq., of Salem, Mass., tells me that he saw a Baltimore oriole and a "small yellow-bird" fly down and eat the grubs.

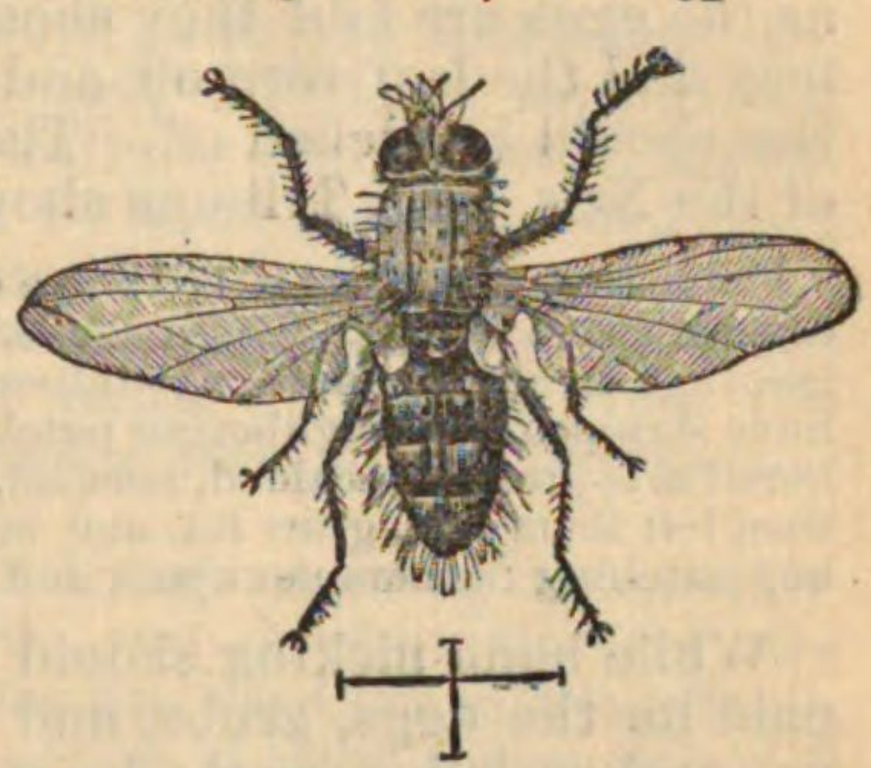


FIG. 12.—Tachina parasite (*Lydella doryphoræ*) of the potato-beetle.

Egg.—The eggs are oval-cylindrical, bright yellow, 0.08 inch long, and laid in clusters side by side, to the number of thirty or forty, on the under side of the leaves.

Larva.—The larva molts three times, four distinct stages occurring with the eggs and beetles in July, either in Colorado or Massachusetts. When first hatched it is deep blood-red, with the head and prothorax dark brown, and with two rows of black spots on the side, the upper row the larger. (In one case the head and prothorax was concolorous with the body, and there was only one row of lateral spots, as in the larva of *L. juncta*). Length, 0.10–0.12. After the first molt it measures 0.17–0.20 inch, and has the same appearance. After the third molt it becomes paler yellowish, and measures 0.25–0.35 inch in length. At this time the body more distinctly than before is seen to be much thicker behind the feet, nearly as thick as broad, while the abdomen is suddenly pointed. The mature larva, when of full size, measures about half an inch (0.40–0.50) in length and is yellow, with the head black, the prothorax yellowish but dark on the hinder edge; two rows of black spots on the side of the abdomen, the two terminal segments of which are dark above, while just behind the head are four small black dots; the legs are black. It matures in about seventeen days after hatching. On comparing about fifty alcoholic specimens in all four stages, from Salem, Mass., taken in July, with the same number collected in Golden, Colo., July 3, I see no difference, unless the latter set are a trifle paler in hue; but some of the Massachusetts examples are as pale as those from Colorado.

Beetle.—Hemispherical, thick-bodied, with prothorax a little narrower than the rest of the body. Yellow; head yellow, sometimes black at the base, with a heart-shaped black spot in the middle; two short diverging black lines in the middle of the prothorax, with smaller lateral dots. Wing-covers with four broad black lines, and the edge of the wing cover lined with black, making ten lines in all. Under side of the abdomen with four rows of black spots. Legs of a reddish tinge, with the ends of the joints dark; tarsal joints dark. Length about half an inch (0.40–0.50).*

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* Though this species was referred to *Doryphora* by Say, and has been retained in this genus by most subsequent authors, it more properly belongs to *Leptinotarsa*. The three species of *Doryphora* in the museum of the Peabody Academy of Science, Salem (*i. e.*, *Doryphora sejeanii* Ger., from Brazil, *D. catenulata* Oliv., from Para, and *D. suturalis* Fabr., from Rio de Janeiro), have a much stouter and thicker body, with a large spine between the anterior pair of legs. In *Leptinotarsa* the spine is entirely absent, and our species (together with *L. craspiena* Kl., from Chiapas, Mexico) are apparently more closely related to the common *Labidomera trimaculata* than to the species of *Doryphora*.

Leptinotarsa juncta (Germar) represents *D.* 10-*lineata* in the Northern and Western States. It may be easily confounded with the latter, but differs from it in the third and fourth lines in each wing-cover (counting from the inner edge of the elytron), being united to form a common band, and the legs are entirely pale yellow, with a dark spot on the thighs (femora). The larva has a lighter-colored head, and but a single row of lateral dark spots. It feeds on the wild potato, not eating the cultivated species. Though first collected in Georgia, it partially inhabits all the Southern States.

Remedies.—The surest and safest remedy is hand-picking. As soon as the eggs are laid they should be looked for on the under side of the leaf and the leaf torn off and burned. Afterward the grubs and beetles should be picked off. The following extract from a correspondent of the New York Tribune shows the efficacy of this remedy:

> From June 7 to August 17 I have caught and killed, by actual counting, over eighteen thousand (18,802) "hard shells," without reckoning the eggs and young ones, on less than a quarter acre of potatoes, so that not a vine has lost its leaves. The bugs have stripped the neighboring patches, and now come swarming on mine. My neighbors Paris-greened, scalded, mashed, and burned bugs till the vines had blossomed, then left them live, grow fat, and migrate. Would it be feasible to fine the negligent bug-catching farmers next year and offer medals to the diligent?

While hand-picking should be practiced and perhaps State bounties paid for the eggs, grubs, and beetles, prizes might be offered by agricultural societies for the largest collections. Co-operation among farmers and others should also be urged, even if legislation should have to be resorted to. President P. A. Chadbourne, of Williams College, advocates higher culture. "Since," he has remarked, "it costs as much to protect an acre of potatoes yielding twenty bushels as one yielding one hundred bushels, less land should be planted and more highly cultivated, as in soil properly tilled it would perhaps not cost more than 5 cents a bushel to protect the potatoes." The aid of fowl should also be invoked, as chickens freely feed on the grubs.

In the Western States the use of Paris green is advocated. This is a preparation of arsenic, and is deadly poison. If used at all in the thickly-settled Eastern States, it should be handled with extreme caution, and only by careful persons, and in gardens and farms where no children are about. One part of Paris green may be mixed with about twenty of cheap flour and dusted over the vines early in the morning while the dew is on the leaves. The simplest way is to sift the flour from a fine muslin bag attached to a pole or from a dredging-box. Although Paris green is freely used in the West, I would not advocate its use in New England on small farms near houses and in the vicinity of large towns. Mr. John H. Sears tells me that several valuable horses and cows have to his knowledge died from this poison. Human life is threatened, as the powder blows about, and the risk of poisoning is too great to be lightly taken.

Various machines have been devised for use on large farms, and liquid preparations and patent sprinklers manufactured for the purpose. Those

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Both *L* .10-*lineata* and *juncta*, the latter inhabiting the Southern States and originally representing 10-*lineata* of the eastern slope of the Rocky Mountain Plateau, are represented in Mexico, Costa Rica, Bogota, and Bolivia by *L.* 11-*lineata* Chevr., in which the head is black and the body darker yellow, but the elytra striped in much the same way, while it is a little smaller. Regarding the generic name of the 10-*lineata*, Dr. Horn writes me "there is some difficulty, but I think all will finally settle down to the name *Leptinotarsa decemlineata*." M. A. Preudhomme de Borre, in his writings on this insect, calls it *Leptinotarsa decemlineata*, and says that it has been improperly referred to *Doryphora*.

who are not inclined to use Paris green may use carbolate of lime, made by mixing in the proportion of half an ounce of crude carbolic acid with a pound of lime, forming a powder, which can be dusted on the leaves. Others have used air-slacked lime with success. Hellebore is ineffectual.

The following suggestions by Prof. H. H. McAfee, of Iowa Agricultural College, are valuable: "We know that the *Doryphora 10-lineata* can only remain healthy and increase rapidly when feeding upon solanaceous plants. Cut off his rations for any considerable length of time and he will surely die; hence if we *plant only early potatoes*, whose tops are all dead by August 10, but few potato-bettles will be found alive on your grounds next season. * * * A word as to how this policy has worked in practice. During the seasons past, in which I have grown 2,100 bushels of potatoes on the Iowa Agricultural College farm, the expense of keeping potato-beetles in check by hand-picking, when they became too numerous, has been less than $2, and no poison has been used and no late potatoes have been grown in my department. Of course where potato-patches are contiguous any patch may suffer from the neighbors' bugs, so that this policy of autumn starvation must be general to be most effective."

Also, as a preventive, it would be well to try planting the prickly solanum (*S. rostratum*) around potato-fields, and asertain whether the beetles would not desert the useful plants for the weed; if so, the culture of the weed would be an invaluable adjunct to that of the potato. A correspondent of the New York Tribune states that the Colorado potato-beetle feeds on the common nightshade (*Solanum nigrum*). To quote his words: "The Colorado potato-beetle troubled the potatoes in my garden very little; but at the side of the garden, close at the ends of the rows, were two or three large shrubs or vines commonly called nightshade. Upon these were hundreds of the slugs of the 'pest,' which seemed to thrive splendidly; and so long as the marauders confine their foraging to this noxious plant I shall not molest them."—(G. H. B., Franklin, N. Y.)

It would be also worth while for experiments to be made in planting not only the common nightshade, but the bittersweet (*Solanum dulcamara*), a common vine imported from Europe, growing in our gardens and about our houses. The horse-nettle (*Solanum carolinense*), a common weed flourishing from Connecticut to Illinois and southward, and upon which the *Leptinotarsa juncta* feeds, might also be planted in broad borders around the potato-fields with probably good results. Whether it is a good policy to heed the natural food-plants of insects, and thus perhaps increase the number of the noxious insects preying upon them, has always been a question in my mind. Still it would be an experiment worth trying in the present case, where it seems almost impossible to increase the numbers of this beetle beyond what they have already attained.

THE YELLOW-STRIPED SYSTENA, *Systena mitis* Le C. var. *ligata* Le C. (Plate LXVI, Fig. 3.)—Eating holes in the leaves and making blotches on them; a small beetle nearly two lines in length; black, with two broad yellow stripes along the back.

This beetle I have only noticed in Colorado, where I observed it in a field of potatoes at Idaho Springs, July 5. It was very abundant on the leaves, eating holes in them and making blotches. As they were pairing it is evident that the eggs are laid at this time, and soon after the larvæ should be looked for, either upon the leaves or at the roots or in the stalk.

Description.—Body rather flat, and rather long and narrow; blackish-brown; head with yellow orbits; a broad dark band between the eyes, and a dark patch behind the

eyes. Antennæ and head in front yellowish; upper lip (labrum) black; both pairs of palpi reddish-brown. Prothorax yellow, especially on the hinder edge, and tinged with brown on the sides and in the middle. Wing-covers black, each with a broad yellow longitudinal stripe one-half as wide as the wing-covers. Body beneath black. Legs yellowish, tinged with brown on the hind femora, which are much swollen, and become paler toward the tip. Length, 0.18 inch, or nearly two lines. The species has been identified by Dr. Horn.

THE THREE-LINED POTATO-BEETLE, *Lema trilineata*, (Olivier. Plate LXVI, Figs. 4, 5.)—Thick-bodied grubs, much smaller than those of the Colorado beetles, feeding on the leaves and disguising themselves with their own excrement, becoming black beetles striped with yellow, and with a reddish head and prothorax.

This beetle need not be confounded with the Colorado beetle, as it is about half the size of the latter, and is only occasionally destructive in the Eastern States, especially New England. The beetle is black, striped with yellow, with a reddish head and prothorax. The grub or larva is a soft-bodied, thick grub, but slenderer than that of *Doryphora*. It conceals itself by covering its body with accumulations of its own excrement. It matures in two weeks, and transforms in the ground, the beetle appearing about the 1st of August. Hand-picking in the early part of July is a sufficient remedy.

BLISTERING BEETLES, *Epicauta cinerea* Fabricius (Plate LXVI, Fig. 6); *E. macrobasis murina* Le Conte; *atrata* Fabricius (Fig. 7); *E. fabricii* Le Conte (Fig. 8).—Long, slender, gray, striped or spotted, or black beetles, with a prominent head, feeding on the leaves, and sometimes even more destructive than the Colorado beetle.

These beetles are allied to the Spanish fly, and, like that insect, all secrete the blistering substance called "cantharadine."

The gray blistering beetles (Plate LXVI, Fig. 6) in Massachusetts appear, according to Harris, about the 20th of June, and sometimes do a great deal of mischief. In the night-time and in rainy weather they leave the plants and burrow at the roots for shelter, and eat in the morning and evening.

Common as these insects are in the beetle state, the larva of some of our native species have not yet been discovered, and the only information available to me is a brief account of the young of the European Spanish fly *Lytta vesicatoria* in Westwood's Modern Classification of Insects, where it is stated that the larvæ live underground, feeding upon the roots of vegetables. "They have the body soft, and of a yellowish-white, composed of thirteen segments, with two short filiform antennæ, and six short, scaly feet."

While the gray blistering beetle is common northwards, the black species, *E. pensylvanica*, is equally or more so, while *E. cinerea* (Forster) (Plate LXVI, Fig. 8,) is more common southward, and *E. vittata* (Plate LXVI, Fig. 9) is very destructive in potato-fields in the Middle, Western, and Southern States.

Epicauta pennsylvanica is perhaps our commonest species northward, and is totally black, and slightly smaller than *E. cinerea*; it is black, but ash-colored on the head and prothorax and on the under side of the body. It occurs as far west as Kansas. (*E. vittata* is longer and slenderer than the others named, and is clay-yellow, with six black longitudinal stripes.)

Macrobasis muria is found west as far as Northern New Mexico, and is to be looked for in Colorado and Wyoming.

The following is Fay's description: "Lake Superior, two males. Easily distinguished by its more sparse pubescence; the thorax is shorter, more convex, and more narrowed anteriorly, and the upper surface is more distinctly punctured; the antennæ are one-half the length of the body, the first joint reaching the occiput, the second joint equal to the two following. With this species I doubtfully associate a female from Missouri Territory, agreeing in form and punctation, in which the

antennæ are a little stouter than in *C. fabricii*, with the second joint about one-third longer than the third."

M. fabricii (*cinerea* of Fabricius) is of a uniform dull-ash color. It is found usually east of the Mississippi, but also occurs in Kansas and New Mexico, according to Dr. Le Conte.

Remedies.—Hand-picking and brushing the insects off the leaves in the morning and evening is the best remedy. Harris says: "I have repeatedly taken these insects in considerable quantities, by brushing or shaking them from the potato-vines into a broad tin pan, from which they were emptied into a covered pail containing a little water, which, by wetting their wings, prevented their flying out when the pail was uncovered. The same method may be employed for taking the other kinds of cantharides when they become troublesome and destructive from their numbers; or they may be caught by gently sweeping the plants they frequent with a deep muslin bag-net. They should be killed by throwing them into scalding-water for one or two minutes, after which they may be spread out on sheets of paper to dry, and may be made profitable by selling them to the apothecaries for medical use."

THE SPOTTED BLISTER-BEETLE, *Epicauta maculata* (Say). (Plate LXVI, Fig. 10.) Feeding on beets and liable to devour potatoes; a light-gray blister-beetle, spotted with black; destructive about Manitou, Colo.

While none of the preceding species have yet been found to be injurious in Colorado or adjacent Territories, there are a number of species of blister-beetles which inhabit the Rocky Mountain Plateau, and two have been found to be injurious to field-crops. While at Manitou during the middle of July I visited a large farm and found this spotted blister-beetle in abundance on the leaves of the beet, and was told that on the 1st of July they swarmed upon the leaves so that "the plants were gray with them." I also found this beetle at Golden, and it is evident that it is destined to be more or less annoying to garden-vegetables and probably potatoes.

Description of the beetle.—Pale yellowish-gray varying to a dark gray, being dark, covered with a gray powder, consisting of minute short hairs when examined under a hand-lens, and finely spotted with black on the wing-covers, the spots being nearly obsolete on the head and prothorax as well as the under side of the body. The legs are of the same color as the rest of the body, but the toe-joints (tarsi) and the tips of the shanks (tibiæ) are blackish, as well as the antennæ and feelers (palpi). It is usually about half an inch long, but varies from a quarter to half an inch. It is rather slenderer in form than any other of the species here named except the striped species (*E. vittata*). It also occurs in Kansas and Eastern New Mexico. This species has been named by Dr. Horn.

THE LEOPARD BLISTER-BEETLE, *Epicauta pardalis* Le Conte. (Plate LXVI, Fig. 11.)—Injuring the potato-leaves in Southern Colorado, and doing more damage locally than the striped Colorado potato-beetle; a beautiful gray-spotted shining-black blister-beetle.

I received from Mr. T. Martin Trippe, a well-known naturalist, numerous specimens of this blister-beetle, with the following account, dated Howardsville, Colo., July 25, 1875:

I send you herewith some specimens of a beetle that has lately destroyed the potato-plant in this vicinity. They are worse than the *Doryphora decemlineata* in the extent and rapidity of their devastations, and seem to have driven the latter out of the country. Before the appearance of this new potato-bug the latter were quite numerous, and had already begun to injure the crops somewhat; but these new-comers stripped the vines in a week, and a few days after they appeared in numbers the *Doryphoras* were nowhere to be seen. No one seems to know of or to have seen them before. Before immersion in alcohol they were spotted with white, the spots being quite small—size of a pin-point; the head unspotted. They feed on wild *Solanaceæ*.

The same remedies may be employed against this and the spotted blister-beetle as suggested for the eastern species.

Description of the Beetle.—It differs from *E. maculata* in being shining black, with pale-gray scalloped lines across the elytra, which unite to form about seven or eight pale-gray irregular ringlets, inclosing black spots, whence the name *pardalis*, or leopard-like. The thorax is black, but gray around the edges, and spotted with gray on the sides and beneath. It is of the usual form, but a little shorter and stouter than *E. maculata*. Length, 0.45 inch. Identified by Dr. G. H. Horn.

THE FLEA-BEETLE, *Haltica* (*Epitrix*) *cucumeris* Harris. (Plate LXVI, Fig. 13.)—Eating holes in the leaves, sometimes riddling them, and causing them to turn rust-color; minute black beetles, which on being disturbed leap off like fleas.

This minute beetle not only infects the potato but also injures beans, beets, tomato-plants, and especially young cucumber-vines. Attacking the leaves when small, and eating round holes in them, by their numbers and the pertinacity of their attacks they each year do much harm, and certain seasons carry off whole beds of young beets and cucumber-vines, as well as seriously injure the potato-plants. The habits of the young of this species are not known, but it is very probable that the eggs are laid on the leaves, and that the larvæ bore into and mine the leaves feeding upon the pulpy substance. The larvæ of other species of the genus known to have such habits are, according to Harris, "little slender grubs, tapering toward each end, and provided with six legs. They arrive at maturity, turn to pupæ, and then to beetles in a few weeks. Hence there is a constant succession of these insects in their various states throughout the summer."

Description.—It is only one-sixteenth of an inch long, of a black color, with clay-yellow antennæ and legs, except the hindmost thighs, which are brown. The upper side of the body is covered with punctures, which are arranged in rows on the wing-cases; and there is a deep transverse furrow across the hinder part of the thorax. (Harris.)

REMEDIES.—Water the leaves with a solution of lime.

THE STRIPED GARDEN BUG, *Lygus lineolaris* (Beauvois) Uhler. (Plate LXVI, Fig. 14.)—Puncturing and poisoning the leaves of the potato and all sorts of garden-vegetables, causing them to wither and turn back; a medium-sized bug.

This bug is very widely disseminated, and is everywhere abundant and annoying in the United States from Maine southward to Alabama, and westward to Colorado and Wyoming. Uhler states that specimens were collected above the timber-line in Colorado by Lieutenant Carpenter; and it occurs on the bald summits of the highest mountains in North Carolina. It hibernates, and in New England appears in April.

Description.—Head yellowish, with three narrow, longitudinal, reddish thorax, bordered with yellow, with five longitudinal yellow lines. The male is much darker-colored; $\frac{1}{5}$ inch in length.

Remedies.—Harris advises sprinkling the leaves with alkaline solutions, such as strong soap-suds, or potash-water, or with decoctions of tobacco and of walnut leaves, or of dusting the plants with air-slaked lime or sulphur.

Besides these insects the sphinx (*Macrosila 5-maculata*) whose horned caterpillar is called the "potato-worm," and the larva of the golden-helmet beetle (*Cassida aurichalcea*) feed on the leaves.

BORING THE ROOTS.

THE POTATO-STALK WEEVIL, *Baridius trinotatus* Say. (Plate LXVI, Fig. 12; *a*, larva; *b*, pupa.)—Boring into the stalks and causing them to wilt and die; a small, white, footless grub.

This is a common insect in the Middle and Western States, where it is at times quite annoying. The female, according to Riley, deposits a

single egg in an oblong slit in the stalk about one-eighth of an inch long, which she has previously formed with her beak in the stalk of the potato. The grub afterward hatches and bores into the heart of the stalk, working downward toward the root, causing the stalk to wilt. When observed to suddenly die the stalks should be cut down and burned.

Beetle.—Bluish or ash-gray, with three shining, black, impressed spots at the lower edge of the thorax. The grub (larva) when fully grown is a little over one-fourth of an inch long, and is soft, whitish, footless, with a scaly head.—(Riley.)

Besides these insects the "potato-worm," or caterpillar of the five-spotted hawk-moth, and the caterpillar of the *Gortyna nitela*, which bores in corn, and the helmet-beetle (*Coptocycla aurichalcea*), which usually feeds on the sweet-potato and morning-glory, occasionally prey on the potato-leaves.

The clubbed tortoise-beetle (*Deloyala clarata*) was found in 1871 by Mr. A. G. Smith, of Berlin, Mass., to be feeding on the leaves of the potato, "eating indifferently different varieties."

THE HAIRY POTATO-MAGGOT, *Homalomyia tuberosa* Curtis? (Fig. 13.)—Feeding in decaying (?) potatoes and cabbages; a flat, hairy maggot, which transforms to a fly like the common house-fly, but paler and smaller.

A few years ago specimens of a hairy maggot taken by Mr. C. A. Putnam August 15, 1875, in defective potatoes, were sent to the museum of the Peabody Academy of Science, at Salem, Mass., and shortly after the museum received a number of maggots of the same species found, July 2, 1875, in the Savoy cabbage, by Mr. John H. Sears, of Danvers, Mass. The latter lot consisted of two broods, *i. e.*, of maggots fully grown, and others one-quarter grown. They are very similar, if not identical, with Curtis's *Homalomyia tuberosa*. Our species is probably the one referred by Harris to the *Anthomyia canicularis* of Europe, and is perhaps, as suggested by Baron Osten Sacken, *H. scalaris*.

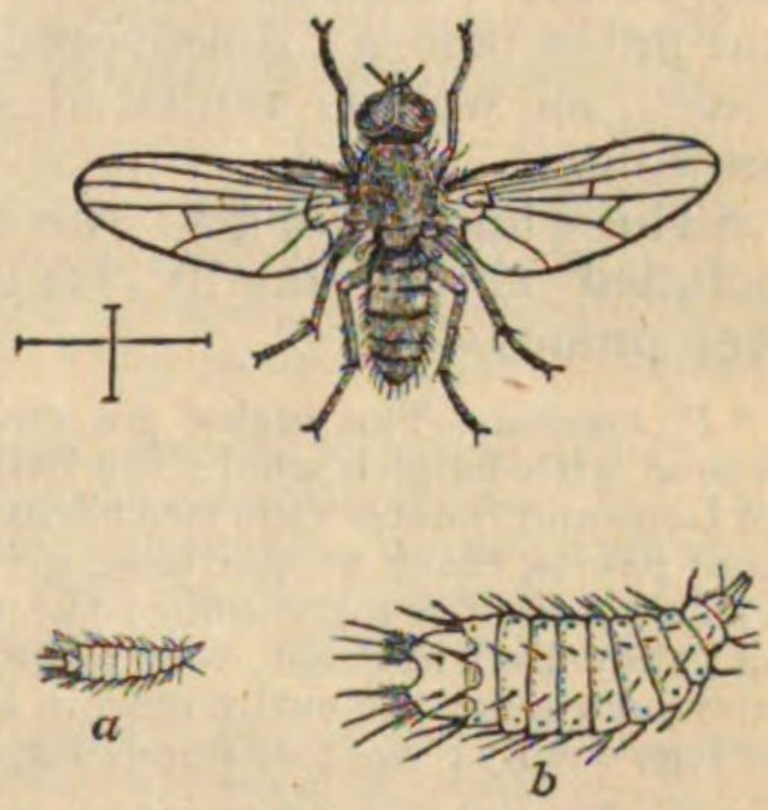

FIG. 13.—Hairy potato-maggot (*Homalomyia tuberosa?*) *a*, larva; *b*, the same enlarged twice. After Curtis.

Description of the larva (Fig. 13: *a*, natural size; *b*, magnified twice).—Head minute, fleshy, not seen in the pupa-case. Body flattened, cylindrical, ovate. Prothoracic segment flat, square, trapezoidal. On the body are two rows of long, slender dorsal spines or hairs, two rows of lateral longer hairs (seen under a high magnifying power to have short spiracles), one subdorsal, the other subvential. The last four dorsal are longer than those in front. The end of the body forms a flat, smooth declivity, on each side of the front edge of which is a thick, stout, short spine (a produced spiracle), much thicker than the others, and ending suddenly in four short, blunt spines. Behind these two spines, on the side of the declivity, are six hairs, with short, slender respiratory hairs on the basal half. Some of the lateral hairs have similar lateral respiratory filaments, but they are less distinct than on the six terminal hairs. The under side of the body is flattened. The spiracles at the base, on each edge of the first segment behind the head, have six long, slender respiratory processes. Length, 0.27 inch. This description will also apply to the pupa-case.

It is easy to see how maggots like these, which bury themselves in cabbages and potatoes, may become swallowed with the food, and if the latter is only partially cooked and hastily swallowed, how the living worms become conveyed into the stomach, and become so annoying that the doctor has to be sent for. The European *Homalomyia scalaris*, or "ladder-maggot," is not unfrequently voided from the bowels of boys and adults in both countries.

I append the following account of several potato-insects of Europe, taken from Curtis's Farm Insects, and which may prove of interest, since the same or closely-allied species are likely to occur in the United States:

"Dead and silent as the earth appears to be, it teems with life; for not only is the soil full of seeds, which merely require light and heat to start them into life, but it must abound with the eggs of insects so minute that even with the assistance of a lens they escape one's notice. To be convinced of the truth of this, if a flower-pot be filled with mold from a field or garden, and then tied over with the finest muslin, the experimentalist will be astonished to find the multitudes of little flies which are constantly making their appearance, bred no doubt from larvæ, nourished on the vegetable matter which such soils contain. Where crops are grown, and any portion of them become decayed, the number of these minute insects is vastly multiplied, and thus where the deceased potatoes have existed additional swarms of various little flies have been the consequence. As a proof of the incredible numbers that must be thus generated, I may mention that from one growing and partially-rotten potato I bred in August, 1845, 128 flies, independent of many more which had died in the pupa state, or been destroyed by damp and mites before I discovered them in the vessel in which the tuber was placed, as well as multitudes of smaller flies, all of which I will now describe.

"The whole belong to the order DIPTERA. The first I shall notice is included in the family TIPULIDÆ and the genus *Psychoda* and has been named—

"*P. nervosa.*—The males are twice as large as the females; they are ashy-white, clothed with longish wool; the little head is buried under the thorax; the black eyes are large and lunatæ; the two horns are as long as the thorax, and composed of eleven (?) small points, black at the base, giving them an annulated appearance; the abdomen is short, and of a dirty color; the two wings when at rest meet over the back slanting; they are iridescent, very large, oval, and lanceolate, with numerous longitudinal, hairy nervures; the entire margin is also hairy; balancers small, clubbed, and white; six legs woolly; the feet fine-pointed, the tips black; length, $\frac{3}{8}$ line; expanse, 3 lines.

"In February, 1846, the larvæ and pupæ were abundant in the rotten potatoes, also in decaying leaves and dung-hills, and the flies have been bred by Mr. Haliday from putrescent fungi. These flies sometimes swarm in out-houses and about drains in spring and autumn.

"The larvæ are not $\frac{1}{2}$ line long, yellowish-white, cylindrical, spindle-shaped, with eleven distinct annulations besides the head, which is triangular; the tail is elongated and tubular. The pupa is about $\frac{2}{3}$ line long, ocherous, and ferruginous; it is elongate-ovate in repose, but the body can be stretched out and attenuated when disturbed; from the forehead project two slender appendages, like horns; on either side are laid the short, stout antennæ, and the wings meet over the breast, with the legs stretched out between them; the abdominal segments are ciliated and the tail is forked.

"Several species of a little swarthy two-winged fly were bred from the decaying potatoes in multitudes. They are called *Sciara* by Meigen and *Molobrus* by Latreille. The larvæ I received from Mr. Graham; they are slender worms, about $\frac{1}{4}$ inch long, whitish, and opaque, but when immersed in water they become perfectly transparent, exhibiting the ocherous viscera and the food digesting in the stomach; when in motion they taper toward the head, which is oval, horny, black, and shining; the body is composed of thirteen segments, with seven or eight spiracles on each side; the tail is broad and rounded, but slightly pointed in the center. The pupa is shorter, cylindrical, elliptical, and of

a dull-ocherous tint, becoming darker as the period approaches of the birth of the fly; the antennæ, eyes, wings, and legs are visible beneath their horny sheaths. At this period they are deprived of locomotion, but the larvæ, although perfect maggots, and destitute of feet, are able to move along in moisture, at the same time waving about and thrusting out their heads with great energy. There are thirty species of these flies which inhabit England, and three or four of them have been bred from putrid potatoes. One is called—

"*Sciara fucata* Meig.—When alive it is 1 line long. The *male* is of a pale inky black, the head is small and spherical, with two triarticulate feelers bent under, the two horns are not longer than the thorax, tapering, pubescent, inserted in front of the face, and sixteen-jointed; two basal joints the stoutest, the remainder oblong, apex conical; eyes lateral, kidney-shaped, and coarsely granulated; ocelli three, but unequal; trunk gibbose, subquadrate, scooped out at the base, with two indistinct lines of short ochreous hairs down the back; scutel lunate, postscutel oval, of a grayish color; abdomen slender, greenish-black, brownish after death, seven-jointed; the margins of the segments pale, apex obtuse, and furnished with two incurved biarticulate lobes; two wings, incumbent in repose, parallel, longer than the body, iridescent, slightly smoky, but transparent and clear at the base; nervures brown, excepting the central one, which is scarcely visible, but forked and dark at the margin; the costal nervure does not reach the base of the forked cell; balancers pale, dirty yellow or ochreous; six legs, long, slender, and of a dirty-yellow or pale-olive tint. *Female* similar, but larger, being 1½ line long, the wings expanding nearly 3 lines, the thorax is not narrowed behind; the abdomen is spindle-shaped, attenuated, and conical, terminating in two little parallel sheaths; the two balancers are dusky when dry.

"This was bred in the winter of 1845–'46, and again in 1848, in vast quantities; the flies are also found throughout the summer in fields and gardens, on umbellate flowers and on grasses. I have likewise bred them from rotten turnips in March.

"*S. quinque-lineata* of Macquart is 1⅓ line long. 'It is black, with five lines on the thorax of a deep dull gray; anterior hips testaceous; wings almost hyaline;' balancers brown or dirty white.

"Specimens agreeing with this description were bred from rotten potatoes in March, 1848, and sent to me with the tubers containing the larvæ and pupæ also. The potatoes were like old rotten cheese, and portions of the outside were covered with slimy threads, which Mr. Graham saw the larvæ spin. He thinks they cause the 'scab' in potatoes; but I saw not the least vestige of the insect on one variety of my potatoes, which was very scabby.

"*S. pulicaria?* Meigen, Hoff., is ½ a line long or upward, and is distinguished from the two foregoing species by its longer antennæ, which are equal in length to the rest of the body. It is black, with testaceous legs; the wings almost hyaline; balancers brown.

"My specimens being as big again as Meigen's, with ochreous balancers, I am doubtful if they be the *S. pulcaria* of that author. I bred them in August, 1845, from a rotten potato.

"Another dipterous insect was bred from the potatoes in less quantities. It also belongs to the family TIPULIDÆ, and the genus *Scathopse*. It appears to be Meigen's.

"*S. punctata*.—It is black and shining, the head is small, the eyes are kidney-shaped, with three little ocelli on the crown; the antennæ are short, stout, cylindrical, and composed of eleven cup-shaped joints; thorax elongated and somewhat compressed, with a white dot on each side; scutel small and rough; abdomen broad, oval, and depressed; wings ample, resting horizontally, transparent and iridescent, with a black. costal, subcostal, and basal nervure, the first and second united beyond the middle, and divided near the base by an oblique nervure; there are also four other very faint longitudinal nervures, the apical one forked, the anal one waved; balancers yellowish; legs simple, longish, and rusty; extremity of thighs and shanks variegated with fuscous; feet brown, five-jointed, terminated by a pair of minute claws; length, 1¼ line; expanse, 3½ lines.

"The larvæ from which these flies proceed live in various putrid substances, and even in dung; they have also been bred from the cocoons of silk-worms, in all probability containing decomposing caterpillars or rotten pupæ; they are from 2 lines to nearly ¼ inch long, flat and narrowed at both ends, of a dirty grayish-yellow color; the head is brown and oval, with two short feelers; the body is composed of twelve pubescent segments, the first thoracic one with a prominent spiracle on

each side as well as the penultinate, which, with the apex, is covered with radiating bristles. The pupa is 1½ line long; it is inclosed in the skin of the larva, and little depressed, and yellowish-brown; from the thorax projects a branched spiracle like a buck's horn, and the tail has a stout spine. It remains from a week to a fortnight in this state, and the flies are often exceedingly abundant in the autumn.

"Two large species of flies belonging to the family MUSCIDÆ I also bred from a single potatoe, as previously stated. There were forty-eight specimens of one which was named by Fallens—

"*Musca stabulaus.*—The *male* is 3½ lines long, and the wings expand ½ an inch; it is of an ash-color, and clothed with black bristles; the feelers are ferruginous; the antennæ drooping, five-pointed, and rust-colored, pitchy at the base, third joint elliptical and heavy, except at the base; the seta black and feathery, the basal joint minute; eyes large, approximating, naked, and chestnut color, the margins silvery white as well as the face, with a black stripe tapering from the antennæ to the three ocelli on the crown; thorax hoary, with four black longitudinal stripes before, the two central ones the longest, with a spot on each side beyond the center; scutel hoary, with a dark stripe at the base, ferruginous at the tip; abdomen ashy-ochreous, shining, the back variegated with brown patches; wings with the apical cell not angulated, but suddenly rounded, scales at the base with pale tawny margins, and concealing the ochreous-clubbed balances; legs black, apex of thighs and tibiæ ferruginous; pulvilli at the extremity of the feet elongated. *Female* similar, but the eyes do not approximate, the face has a yellow tinge, and the stripe on the crown is broad and elliptical; the abdomen is broader, with an oviduct at the tail, and the pulvilli are small.

"The maggots had bred and accumulated among the slimy matter of the rotting potato, just as meat-maggots are found, together with the horny pupæ. Indeed, the largest maggots were exceedingly like those of the flesh-flies, being flat and whitish, the ochreous food and white lines of viscera shining through the transparent skin; the head was pointed with a black proboscis formed of two horny claws, and the two spiracles at the blunt tail were like two black horny knobs. The tough and oval pupæ were of a bright chestnut color, the segments slightly marked, the head end rounded and wrinkled to a point; the tail furnished with two black specular tubes.

"Of the other fly I bred fifty-eight specimens from the same potato in the middle of August. The larvæ escaped my notice at first from being so very like the earth in color, and they are still more difficult to detect from their sluggishness. They must be in the greatest force in July, but I have met with them in rotten potatoes in the end of November. The group of flies with these singularly spiny larvæ have been formed by Bouché into a genus called *Homalomia*, being a section of *Anthomyia*. The parent fly of our species is exceedingly like *Musca cunicularis* of Linnæus; still there are differences, and as the larvæ are also dissimilar, I have named this potato-fly—

"*Anthomyia tuberosa.*—The *male* is 2½ lines long, and expands 5½; it is grayish-black and bristly; the eyes are chestnut color, naked, approximating on the crown, the inner margin silvery white; antennæ drooping, five jointed, third joint oblong, fourth a slender elongated basal joint to the longish pubescent seta; thorax with five indistinct broad stripes down the back, second and third abdominal segments with bright ocherous spots on each side, third rarely with two similar minute spots; wings transparent, nervures dark, the two transverse ones not very remote; balancers pale tawny; legs black, base of shanks indistinctly ferruginous. *Female*, ashy slate-color; the eyes smaller than those of the male and remote; the face not silvery; thorax with five distinct broad blackish lines down the back; abdomen ovate-conic, with two indistinct ocherous slightly-diaphanous spots on the second abdominal segment; in other respects this sex is similar to the male.

"The larvæ, although indolent, can crawl well; they are of a dull tawny color, clothed with long bristly spines, somewhat depressed, elliptical, tapering to the head, which is waved about, and when thrust out is whitish and fleshy, armed with two minute hooks like ebony, and

there is a little fleshy horn on each side; on the following segment is a spiracle on either side, surrounded by several stout short rays; the two next segments have tubercles on the back; the remainder have a double series down the center, producing bristles, with a double row on each and eight of the segments have a pair of short spines each beneath, which enable it to walk; the apex is armed with six long bristles a little spiny at the base, but most of the others are naked, or with the slightest appearance of pubescence or little spines at the base; on the apical segment are two spiracular tubes. The pupa being formed within the indurated skin of the larvæ, it varies from it only in being more convex above, and the fly escapes by a lateral opening in the thorax.

"These larvæ and purpæ I find occasionally in my garden where cabbages have long occupied the ground, and Dr. Harris remarks that the hairy maggots of *Anthomyia cunicularis*, or an allied species, live in rotten turnips; they also abound in privies, and the purpæ-cases are found in multitudes under boards.

"From the large quantities of these maggots which have been ejected from the human stomach and intestines, accompanied by the most distressing symptoms, I am led to conclude from their economy that the eggs or larvæ are conveyed into the stomach in badly or half cooked vegetables, for it is evident they subsist upon decomposing vegetables and excrementitious substances, and I have found similar but very small larvæ on cabbage-leaves in October. It is, therefore, very probable that, under certain morbid conditions of the constitution, they are able to live in the human body until they have arrived at their full growth, when they are necessarily ejected to become pupæ, and after a short time to be transformed into flies. It is not a little remarkable that the maggots of *Musca stabulans* should have been also voided from the intestines, and that fact tends to substantiate the view I have taken of the subject and the cause of their presence in the human system, for that is the other species of large fly which I bred from maggots generated in the same potato.

"I also detected the larvæ and pupæ of a smaller species of fly called *Drosophila*, which hatched in the middle of August with the foregoing insects. They are also inhabitants of cellars, as their specific name implies, where the larvæ are usually very abundant all the year round. They will breed in stale beer, and probably are generated where there is any leakage from the tap and oozing about the bung, as well as from the fungi which spring up round rotten wood, etc., in cellars. I have also known them to be bred from vinegar, and it will be remembered that one species, *D. flava*, lives on the pulpy substance of the turnip-leaves, and another, *D. graminum*, I have bred from cabbage-leaves. In spring and autumn the flies abound, and are not unfrequently on the inside of our windows. They belong to the family MUSCIDÆ and the genus *Drosophila*. That bred from the potatoes appears to be the Linnean species named

"*Drosophila cellaris.*—It is 1½ line long, and expands 4 lines; the general color is ochreous; the head is broad as well as the face, in the center of which are inserted the two little drooping pubescent horns, the third joint is oval, and from the back arises a feathery bristle jointed at the base; the orifice forming the mouth is very large; eyes large, hemispherical; ocelli three on the crown; thorax globose-quadrate; scutal semi-ovate; abdomen small, depressed, oval, blackish, and six-jointed, with four or five ochreous bands; the apex pointed in the female; wings incumbent in repose, very long, and ample, yellowish and iridescent, with a very short marginal cell, and four longitudinal nervures, the second and third united toward the base, the third and fourth toward the margin; balancers small, clavate; six legs, tapering; feet long, slender, and five-jointed, terminated by minute claws.

"The larvæ are 2½ lines long, of a whitish color, tapering toward the head, composed of twelve joints; on each side of the thoracic segment is a short branching spiracle, and the tail is furnished with four divaricating blunt spines, the edges of the segments being serrated with hooked ones. When full grown this skin becomes horny, changing to a rust color, the maggot is transformed to a pupa within an internal horny shell of a chestnut color, and of course the pupa greatly resembles the larva.

"There is also an extensive group of flies called *Borborus*, the larvæ of which live upon decomposing vegetables, and probably animal substances also; at all events they are generated in fungi. A portion of these flies is now distinguished by Macquart, under the generic name of *Limosina;* one of them I have bred from rotting potatoes, and it seems to be identical with that author's—

"*L. geniculata.*—It is only 1 line long, and expands a little more than 2 lines. It is black; the head is moderately large, with an ample cavity beneath to receive the mouth; the eyes are hemispheric and rust-colored, and there are three minute ocelli on the crown; the face is concave, with two little horns in the center, the third joint orbicular, with a tomentose seta; thorax broader, very convex; scutel semi-orbicular and flat; abdomen very short, the segments equal in length; wings rather small, smoky, nervures pitchy; costal the strongest; submarginal cell not extending to the apex, second and third longitudinal nervures united at the middle, third and fourth forming a loop with two minute branches at the extremity; balancers small and ochreous; legs pitchy; hips ochreous, as well as the tips of the anterior thighs and the base of the shanks; hinder with a few spines outside; feet long, five-jointed, especially the hinder, which are slender and longer than the shanks; dull ochreous, basal-joint very long and pitchy, terminal one very short, and furnished with short claws.

"M. Rayer also observed a species in the infected potatoes which has been named by Guérin *Limosina payenii*, and it is not improbable that it may be the male of Macquart's species, for it agrees very well with our female, except in the color of the wings and the structure of the hinder feet.

"With the foregoing *Diptera* I often bred a parasitic insect in considerable numbers, but to which it is attached, or whether to any of them, I am unable to ascertain. It belongs to the order HYMENOPTERA, the family PROCTOTRUPIDÆ, and the genus *Cerapsilon*, which has been divided by Mr. Westwood into three genera, one of which is called *Paramesius*, and to that section our insect belongs. It is included by Nees ab Esenbeck in the genus *Diapria*, and has been named by him—

"*P. brachialis.*—The *male* is scarcely 1 line long and expands 1⅔; it is very glossy black; the head is globose, the face short, ovate, and at the bottom are attached the antennæ, which are nearly as long as the body, ferruginous and fourteen-jointed, basal joint long, second short, obovate, third notched or comma-shaped, remainder short and obovate, apical joint conical; eyes small, lateral, with three ocelli on the crown in a triangle; thorax very globose, scarcely larger than the head; scutel small, semi-oval, deeply hollowed at the base; metathorax ferruginous and uneven; petiole forming a ferruginous knob, woolly behind; abdomen small, ovate-conic, pitchy, base ferruginous, with four longitudinal channels on a very large segment, apical segment very short; fore wings dusky and pubescent, with a few nervures at the base of the superior, forming an elongated cell; six legs short, slender, and ochreous, pitchy at the base; thighs thickened, as well as the anterior shanks, and pitchy at the middle; feet slender, five-jointed, tips dusky. *Female*: Above 1 line long, and expanding 1¾; this sex is not only distinguished by its larger size, but the horns are shorter, with only twelve joints, the third being simple like the second; and the extremity of the abdomen is acuminated, and very acute.

"This insect belongs to a family which is very serviceable in keeping down wire-worms and other subterranean larvæ, as will be seen by a reference to a former chapter and the Gardener's Chronicle. Nees also says that the *Diapriæ* breed in the subterranean larvæ of *Tipulæ*, or gnats.

"I must not omit to record another fly, called *Dilophus febrilis*, which is exceedingly abundant every year, the larvæ causing much mischief

in gardens; and at the close of the year 1845, many of them were sent to me as abounding on decayed portions of planted potatoes, and I have met with them likewise about the tubers and in flower-pots, where they burrow in all directions. Some I received in July were about ¼ of an inch long, of an ochreous-brown or snuff color, and shagreened; the back is slightly convex, with twelve well-defined wrinkled segments, and a horny, shining head, much narrower than the body, intensely black or inclining to chestnut color, and slighty hairy; there are eight distinct spiracles on each side, the penultimate segment is rounded, with four teeth on the margin, and the anal one has four smaller teeth, with two large spiracles near the base; it has no feet.

"They were transformed to pupæ in the earth in the beginning of August, and were then yellowish-white; the thoracic portion was very thick, with two horns in front; the body slender and subcylindric, the segments very distinct, with spiracles down the sides, and the tail spiny.

"The flies hatched on the 21st of August, but they abound in fields, hedges, especially under trees, and even in the highways around London, the whole of that month; and there must be two broods of them, as they are found likewise in May. They belong to the family TIPULIDÆ, and to the genus *Dilophus*. The species was named *febrilis* by Linnæus, from the generally-received opinions in Sweden of these flies resorting to houses where intermittent fevers existed.

"*D. febrilis* is intensely black, shining, and hairy. The head of the *male* is hemispheric, and covered with large densely pubescent eyes of a reddish-brown color. There are three minute ocelli forming an elevated triangle near the base; the tip is broad, and the feelers incurved; the trunk is oval and gibbose, with two transverse rows of minute teeth before; the scutel is short and broad; abdomen sublinear, eight-jointed, the apex clubbed; the two wings are incumbent in repose, perfectly transparent and white but iridescent, the pinion only is slightly tinged with brown, the costal nervures pitchy, the others very faintly marked; a radial nervure uniting with the costa at the middle forms a brown spot at the extremity; two balancers, with a large compressed brown club; it has six long legs; anterior thighs the thickest, the shanks very short, the apex surrounded by a coronet of teeth. There are also several short spines outside; feet slender, five-jointed, terminated by claws and suckers; length, 2½ lines; expanse, 5 lines. The *female* is larger and very different, the head being much less, with small oval eyes not meeting on the crown; the abdomen is brownish and elongated, ovate at the extremity but narrowed at the base, and the tip is furnished with two minute tubercles; the wings are much longer and very ample, entirely brown, the pinion being the darkest, with a brown stigmatic spot; all the nervures are pitchy; the anterior thighs are incrassated.

"These insects fly heavily, their hinder legs hanging down, and in the evening they become sluggish, resting on herbage and bushes. The larvæ also inhabit cow-dung and horse-muck; it is therefore very possible they may be introduced into potato-grounds with the manure, or the flies may be attracted to highly-manured ground to deposit their eggs; for so little is known of the economy of many insects, that it is impossible to determine their exact habits; indeed, no description or figures were to be found of the larvæ and pupæ of this fly until I sent them to the Gardener's Chronicle."

INJURING THE SWEET-POTATO.

THE HELMET-BEETLE, *Coptocycla aurichalcea* (Fabricius).—Feeding on the leaves; broad, flattened, spiny grubs, holding their cast-off skins over their backs.

This beetle, which usually feeds on the leaves of the morning-glory, will sometimes destroy whole fields of sweet-potatoes, and is specially injurious to plants transferred from hot-houses.

The larva is broad and flat, with a row of large, long, barbed, spines along the edge of the body, sixteen on each side, the two posterior of

which serve as a fork to hold the cast skin, covered with excrement, over its body, probably as a protection from its enemies, the birds. The eggs are irregular, flattened, with three spines behind, sometimes, however, wanting, and they are laid on the leaves. The larva matures in three weeks after hatching, molting three times. The larva, when about to change to a pupa, adheres by a mass of silk to the surface of a leaf, with its cast-skin about it. The pupa is smooth, its tail movable, and the limbs, according to Riley, are soldered to the body, as in the chrysalids of moths and butterflies. The pupa state lasts a week. In Massachusetts, during the last week in July, I have found the larvæ in all stages of growth very abundant on the morning-glory (*Convolvulus*), eating holes in the leaves. They pupated late in July and early in August; the beetles appear from the 7th to the 12th. Hand-picking is obviously amply sufficient to destroy them if too numerous.

Description of the beetle.—Of a rich amber-yellow, with a reddish tinge over the body. Two black spots on the back and two on each side, disappearing a few days after casting off the pupa-skin. The wing-covers are ornamented with finely-impressed punctured lines. Body beneath shining black; antennæ pale on the basal half, dark beyond. Legs pale amber. Length a little less than a quarter (0.22) of an inch.

THE TWO-STRIPED SWEET-POTATO BEETLE, *Cassida bivittata* Say.—In the Western States the most common helmet-beetle found on the sweet-potato, and, according to Mr. Riley, feeding exclusively upon it, is the above-named beetle. The grub or larva is dirty-white or yellowish-white, with a more or less intense neutral-colored longitudinal line along the back, usually relieved by an extra light band on each side. It differs from the larvæ of all other known species in not using its fork for merdigerous purposes. Indeed, this fork is rendered useless as a shield to the body, by being ever enveloped, after the first month, in the cast-off prickly skins, which are kept free from excrement. The beetle is of a pale yellow, striped with black. (Riley.) Besides these two helmet-beetles, two other species (*Cassida nigripes* and *Coptocycla guttata*) prey to a certain extent upon the sweet-potato. The cucumber flea-beetle, *Epitrix cucumeris* (Harris), and a few caterpillars are said by Riley to feed on this plant. Besides these, Harris states that plant-lice sometimes infest the leaves, and to drive them off he recommends dusting the leaves with lime.

INJURING THE ONION.

THE ONION-FLY, *Anthomyia ceparum* Meigen. (Plate LXVII, Fig. 1.)—Killing the tops, causing them to turn yellow and wilt; a smooth, conical, white maggot, attacking the bulb soon after the leaves appear early in June, and afterward through the summer, and changing to an ash-gray fly, a little smaller than the house-fly, and with a row of black spots along the middle of the hind body, which lays its eggs on the leaves, close to the earth.

The onion-fly has been an inhabitant of this country for about forty years, having been imported from Europe. Fitch remarks that "in many parts of New England and New York it was extremely numerous and destructive about the year 1854, and again in 1863." In Essex County, Massachusetts, it has been for a number of years, and still is, very annoying and destructive. Having had little opportunity of observing the habits of this fly, I avail myself of the quite full account given by Dr. Fitch in his Eleventh Report on the Noxious Insects of New York, often using his own words: "In June, as soon as the young seedling-onions are only an inch or two in height, these insects commence their depredations and continue them through the whole season, getting their growth and coming out in their perfect state one after another,

whereby some of the flies are liable to be always present in the garden, in readiness to deposit their eggs; and maggots of widely-different sizes are commonly met with in the same onion.

"The eggs or 'fly-blows' are loosely placed upon the onion slightly above the surface of the ground (Fig. —), some of them being dropped along the thin edge of the sheath or white membranous collar, which is formed by the base of the lower leaf clasping around the stalk, and others are crowded into the crevices between the bases of the leaves, slightly above where they issue from this sheath. From two to six or more eggs are usually placed on particular plants here and there through the bed. They are perceptible to the eye, being white and smooth, four-hundredths of an inch (0.04) long, and a fourth as thick, and of an oval form." When the minute maggot hatches from the egg, it works its way downward inside of the sheath, its track being marked by a slender, discolored streak, till it reaches the root, on which it feeds till it is wholly consumed, only the thin outer skin remaining. After eating the bulb of one plant they attack the next, until sometimes a third or a half of the bed is destroyed.

The first indication that the plant has been attacked is afforded by the leaves turning yellow and wilting. "On carefully digging up and examining the affected plant, if it is young and the root small and cylindrical, we commonly find it completely cut asunder as represented in Fig. —, only the thin outer skin remaining, whereby the slightest pulling upon the top draws it up out of the ground. Later in the season, when the round bulb is beginning to be formed, as in Fig. —, we find a hole perforated in its side, opening into a cavity in the interior, and the earth around this perforation is wet and slimy, forming a mass of filthy mud in which those worms are lying which are not engaged in feeding. And by this interior cavity the central leaves of the plant are severed from their connection with the fibrous rootlets, as shown in the figure, whereby it is now these central and not the outer leaves which first turn yellow and die, and all the upper portion of the root soon becomes soft and putrid, while the bottom part, continuing to be nourished by the fibrous rootlets, remains sound, and the worms now crowd into this part to feed, whereby it sometimes presents a wonderful appearance, being thronged with worms wedged together side by side in a compact mass, all with their heads downward, eagerly consuming the last remains of food there is there, and only the rounded hind ends of their bodies exposed to view, these forming an even surface similar to the cobble-stones of a street-pavement, as represented in Fig.—."

The maggot attains its growth, in summer, in about a fortnight, and changes to a pupa either in the cavity in the onion or in "the wet, slimy earth which is in contact with the onion. It here ceases to move, it becomes contracted and shorter in length, its skin hardens and changes to a tarnished yellow and finally to a chestnut color with a stain of black at each end." This is the pupa-case, and the true pupa is inside. In this condition it lies about two weeks before the fly escapes.

In Essex County, Massachusetts, this fly is very destructive. The maggots appear about the middle and last of May, and by the third week in August the larvæ are not found, only the pupa-cases.

Description.—The larva or maggot is shining, dull white, cylindrical, tapering to a point in front, and when crawling and elongated, nearly the whole length of the body becomes tapering. At the forward end the jaws appear under the skin as a short black stripe. The hind end is cut off abruptly in an oblique direction, forming a flattened surface, on which, slightly above the center, are two elevated dots of a cinnamon-brown color, and appearing somewhat like a pair of eyes; and around the margin are eight small projecting teeth, of which the two lowest ones are largest; and a little forward

of these, on the under side of the body, are two additional teeth, like minute feet, by the aid of which the maggot shoves itself forward when crawling. (Fitch.) Specimens from Essex County, Massachusetts, are long, conical, the end of the body squarely docked, with barrel-shaped spiracles projecting from the end of the body. On the under side of the segments are raised folds, one to each segment, and of service in locomotion. The spiracles and termination of the tracheæ or air-tubes are very distinct on the prothorax, while there are no traces of antennæ. The fly is like the common house-fly, but smaller and slenderer. The two sexes are readily distinguished from each other by the eyes, which in the males are close together and so large as to occupy almost the whole surface of the head, while in the female they are widely separated from each other. These flies are of an ash-gray color, with the head silvery, and a rusty-black stripe between the eyes, forked at its hind end. The species is particularly distinguished by having a row of black spots along the middle of the abdomen or hind body, which sometimes run into each other, then forming a continuous black stripe. This row of spots is quite distinct in the male, but in the female it is very faint or is often wholly imperceptible. This fly measures 0.22 to 0.25 inch in length, the females being usually rather larger than the males. (Fitch.)

Remedies.—As a preventive measure worth trial the seed should be sown two inches deeper than usual, so that the fly cannot so readily get to it to lay its eggs. Sow also on ground on which straw has been previously burned. Rotation of crops is also a most important preventive measure. When the roots are infested pour boiling water along the drills near the roots, or even on the plants, going over the bed four times during one season. The diseased onions should be pulled up and burned. Fitch recommends cultivating the onions in hills, scattered among the other vegetables in the garden. "With only three or four seedlings in a hill it is evident that the young worms could nowhere find a sufficient amount of food to nourish them to maturity. Having consumed all the young plants in one hill, they will be unable to work their way through the ground to come at another hill except it be by the merest chance, and will thus perish."

THE BLACK ONION-FLY, *Ortalis flexa* Wiedermann. (Plate LXVII, Fig. 2.)—Infesting the bulb in the Western States; a more slender, less conical maggot than the European onion-maggot, with the head blunter; killing the tops and causing the onions to decay; changing to a black fly, with three oblique white stripes on each wing.

This native onion-fly was first found to be destructive to onions in Illinois by Dr. Henry Shimer, who writes in the Practical Entomologist (i, 4) as follows regarding it: "In the latter part of June I first observed the larva or maggot among the onions here; the top dead, tuber rotten, and the maggots in the decayed substance. From them I bred the fly. They passed about two weeks in the pupa state. At that time I first observed the flies in the garden, and now few are to be found. Their favorite roosting-place is a row of asparagus running along the onion-ground, where they are easily captured and destroyed, from daylight to sunrise, while it is cool and wet. During the day they are scattered over the ground and on the leaves and stalks of the onions, and not easily captured. Their wings point obliquely backward, outward, and upward, with an irregular jerking, fan-like movement; flight not very rapid or prolonged. They are not very numerous, probably not over 200 or 300. All that I observed originated in one part of the bed, where they were doubtless deposited by one parent fly. Two broods appear in a season."

THE ONION-THRIPS, *Limothrips tritici* Fitch. (Plate LXVII, Figs. 3-5.)—Attacking the leaves, causing them to turn yellow and wilt and die; minute, yellow, slender insects, living on the leaves in all stages of growth.

The following account is taken from my Second Annual Report on the Injurious and Beneficial Insects of Massachusetts:

"About the middle of August my attention was called by Mr. B. P.

Ware, of Swampscott, to his serious loss of onions from the attacks of a minute insect. The leaves were observed to suddenly turn yellow and wilt, and the plant died. In this way large patches became infested and turned yellow, until in two or three days these prolific insects spread over the whole field. They seemed to increase most rapidly during the unusual dry, hot weather that we experienced about the middle of last August. On the 11th of August a whole acre was thus cut off. Mr. Ware informed me that the onion-plants have been more or less infested in this way for some fifteen years, but the damage done this year was greater than ever before. This evil seems wide-spread in Essex County, as not in Swampscott alone, but in Lynn, Salem, and parts of Danvers, the onion-crop has been similarly infested. About $100,000 worth of onions are raised in Essex County alone, and Mr. Ware judged that at least a tenth part was destroyed by this new pest; so that in one county alone and by one kind of injurious insect we have in one season lost $10,000. The onion-crop is next to the hay-crop in value, as it is sold for cash.

"On examining the specimens brought into the Museum of the Peabody Academy of Science the leaves were found to be covered with hundreds of a minute thrips, which, by gnawing the surface of the leaves, had caused them to turn white in spots, and subsequently yellow; where they were most numerous the outer skin of the fleshy leaves was entirely eaten off, and though it was difficult to imagine that so minute insects could have caused the death of so stout and thick-leaved a plant, yet here were hundreds of the culprits in all stages of growth plying their jaws before our eyes in proof.

"This insect, which occurred in both sexes and in all stages of growth from larvæ of minute size, proved to be the wheat-thrips of Fitch (*Limothrips tritici*), who gives an account of its appearance and habits in his 'Second Report on the Noxious, etc., Insects of New York,' p. 304. His attention was first called to this insect by a correspondent in Wisconsin, who found them in great numbers in blossoms of various plants. He wrote Dr. Fitch that they first 'made their appearance about the middle of June, or at least they were then first noticed, so far as I have heard. For about two weeks they were found in the blossoms of wheat and of clover, causing numbers of the blossoms to wither, and in some cases the kernel was also attacked.' Dr. Fitch himself never seems to have noticed this insect in New York, nor that it has ever been found in the onion, but thinks it is the species to which Dr. Harris refers in his treatise. In that work the author speaks of a 'pernicious insect in the ears of growing wheat,' which 'seems to agree with the accounts of the *Thrips cerealium* which sometimes infests wheat in Europe to a great extent.' From his brief description it is probably the insect now under consideration to which Dr. Harris refers.

"The various kinds of thrips are minute, narrow-bodied insects seldom exceeding a line in length, and remotely allied to the bed-bug and squash-bug in structure, but differing from them in having free jaws adapted to biting, while those of the bed or squash bug form with the other mouth-organs a sharp, hard beak, with which they puncture leaves, or the flesh of their victims, when carnivorous in their tastes. These thrips are further distinguished by their wings being very long and narrow, and beautifully fringed; and when folded over their back they do not conceal the body beneath, as is usually the case. Moreover, they are exceedingly active in their habits, running or leaping like fleas.

"*Description.*—The females alone are winged, the males being wingless and closely resembling the larvæ. The body of the female is smooth and shining, uniformly green-

ish-yellow, with no other markings; the legs are a little paler toward the articulations. The antennæ are eight-jointed, slightly longer than the head; the two basal joints are the largest; the three succeeding joints equal, regularly ovate, the sixth a little longer than the fifth; seventh and eighth minute, seventh a little shorter than eighth, each joint bearing four large bristles. This species differs from the European *L. cerealium* in having but eight joints, the seventh and eighth being minute, and with no intermediate short one, as described in the European insect.

"The prothorax is square, the scutellum short, crescent-shaped, and the abdomen is long and narrow, smooth and shining, ten-jointed. Length, four one-hundredths of an inch, or less than half a line.

"The larva (Plate LXVII, Fig. 4 *b*) is entirely greenish-yellow, the head and prothorax of the same color as the rest of the body; the eyes are reddish; the feet and antennæ are whitish, not annulated, as in *L. cerealium;* the feet (tarsi) consist of but a single joint ending in a point.

"The male (Plate LXVII, Fig. 4 *a*) differs from the larva in having two-jointed feet (tarsi) and seven-jointed antennæ, those of the larva being four-jointed. The second joint is exactly barrel-shaped, with two ridges or lines surrounding it, third and fourth joints long, ovate, the third being a little larger than the fourth, and with about twelve transverse lines, there being about eight on the fourth joint, from the end of which projects a remarkable tubercle, as seen in the figure. The fifth joint is square at the end, with about eleven transverse lines, and three or four stout hairs externally; sixth joint minute and spherical, while the seventh is three times as long as the sixth, and is finely striated, and with four unequal stout hairs. It is just twice the length of the female, measuring 0.08 inch.

"*Remedies.*—The best remedy of a preventive nature against further ravages, after this insect has made its appearance, is to build a bonfire upon the diseased patch, pull up the onions about, and throw them into it. By thus sacrificing a few onions at the outset, the evil may be nipped in the bud. As remedies less effective we would recommend showering the plants with strong soap-suds, or sprinkling them with sulphur, or the use of a solution of copperas, such as is used in killing the currant saw-fly, *i. e.*, a solution of a pound of copperas to ten gallons of water. The use of a carbolate of lime or air-slaked lime may also be recommended.

"A heavy shower of rain will cause them to disappear for a while, and they probably only appear in such overwhelming numbers as this past year in consequence of the summer being an unusually dry and warm one."

INSECTS INJURING THE TURNIP.

THE TURNIP FLEA-BEETLE, *Haltica* (*Orchestris*) *striolata* Illiger.—Feeding on the seed-leaves in the spring and later; small, yellow-striped, flea-beetles. In June, the plants die from the attacks of the grubs which live in the roots.

This is a very annoying little beetle, universally abundant in gardens, and especially injurious to the seed-leaves of the turnips, cabbage, and other garden-vegetables. The fullest account which we have of its habits is that given by Dr. Shimer in the American Naturalist, vol. 2, p. 514, which I copy:

"This beautiful little beetle, also called striped turnip-fly (*Haltica striolata* Fabricius) at the West, is well known and abundant. Every gardener is conversant with the fact that, like fleas, grasshoppers, etc., it springs away to a great distance when he attempts to put his finger upon it. It appears in early spring, and is a constant annoyance to the gardener during the whole summer.

"From my notes I see that on June 14, 1865, I put a number of the larvæ into a breeding-box, with a supply of their natural food. June 17 some of the larvæ had disappeared beneath the ground. July 4, I found in the box the beetle. This gives us seventeen days from the time the larva entered the ground, having ceased eating, until I obtained the perfect insect. I did not open the breeding-box every day,

but as the insect was yet quite pale and soft, conclude that it was not more than a day or so out of the ground. The actual time, however, in the pupa state, was less than seventeen days, for, like the larva of the cucumber-beetle and other beetles, these worms pass a kind of intermediate state, in a quiet, motionless condition, in their little dirt-tombs beneath the ground. During this time they decrease in length very much, becoming a shorter, thicker 'grub.' This period is a peculiar part of the larval state, and may be called the quiescent, or 'shortening period,' in contrast with the feeding period. At the end of this preparatory shortening period, the little larva casts its skin and becomes a pupa.

"During the past summer I bred a good number of these beetles from the larva and pupa, taken from their breeding-places beneath the ground; but as I took no precise notes of the date, I can say no more regarding the time of the pupa state, except that it is short, only a few days.

"Every gardener knows that these insects are very injurious to young cabbages and turnips as soon as they appear above the ground, by eating off the seed-leaves; he also almost universally imagines that when the second or true plant-leaves appear, then the young plant is safe from their depredations, then the stem is so hard that the insect will not bite it, and the leaves grow out so rapidly as not usually to be injured by them; but if we would gain much true knowledge of what is going on around us, even among these most simple and common things, we must learn to observe more closely than most men do.

"The gardener sees his young cabbage-plants growing well for a time, but at length they become pale or sickly, wither and die in some dry period that usually occurs about that time, and attributes their death to the dry weather; but if he will take the pains to examine the roots of the plants, he will find them eaten away by some insect, and by searching closely about the roots will find the larva, grub, worm, or whatever else he may choose to call it; from this he can breed the striped turnip-beetle, as I have often done.

"I have observed the depredations of these larvæ for ten years, and most of that time had a convincing knowledge of their origin, but only proved it in 1865; since that time I have made yearly verifications of this fact.

"Every year the young cabbage-plants and turnips in this region receive great damage from these larvæ, and often when we have dry weather, in the latter part of May and early in June, the cabbage-plants are ruined. A large proportion of the plants are killed outright in June, and the balance rendered scarcely fit for planting; but when the ground is wet to the *surface* all the time by frequent rains, the young plant is able to defend itself much more effectually, by throwing out roots at the surface of the ground, when the main or center root is devoured by the larva; but in the dry weather these surface roots find no nourishment and the plants must perish.

"This year I saw these beetles most numerous in early spring, but have often seen them in August and September so abundant on cabbages that the leaves were eaten full of holes and all speckled from their presence, hundreds often being on a leaf, and at this time the entire turnip-crop is sometimes destroyed by them, and seldom a year passes without their doing great injury."

These observation are not entirely in accordance with the teachings of the masters in entomology. From Westwood's Introduction we learn that the *Chrysomelians* feed on the leaves of plants; that some of them attach themselves to the leaves to transform, and that others descend

into the ground for this purpose; but he has no notes of species feeding beneath the ground. Harris was of the opinion that the striped cucumbre-beetles, in the larval state, fed on the roots of plants, but was never able to find them. I have demonstrated many years ago that they feed on the roots of melon, cucumber, squash, and pumpkin vines, and ever since I attempted to raise any kind of vine my greatest trouble has been *not to find them.*

"The *Chrysomelians*, probably, as a rule, feed on the leaves of plants in the larval state, but in my limited researches I have found the majority of them beneath the ground. According to undisputed authority, they often congregate together in great numbers and do great injury to the leaves of plants, even so as to compare with the ravages of caterpillars. I, myself, have observed some of this work.

"As the cucumber-beetle exclusively raises its young on the roots of the *Cucurbitaceous* (gourd) family, so from these observations I am led to believe from analogy that the striped turnip beetle raises its young always on the roots of the *Cruciferous* (mustard) family.

"The striped turnip-beetle (Fig. 14) is less than one-tenth of an inch in length. Its general appearance is black, with a broad, wavy-yellowish or buff colored stripe on each wing-cover. The larva (Fig. 14) is white with a faint darkened or dusky median line on the anterior half of the body, being probably the contents of the alimentary canal seen through the semi-translucent skin. The head is horny and light brown. On the posterior extremity is a brown spot equal to the head in size; and there are six true legs and one proleg. In its form and general appearance it somewat resembles the larva of the cucumber-beetle, but it is much smaller. Its motion is slow, arching up the abdomen slightly, on paper or any smooth surface, in such a position that its motions are necessarily awkward and unnatural, because in a state of nature it never crawls over the surface, but digs and burrows among the roots in the ground. Its length is 0.35 of an inch, and breadth 0.06 of an inch. It feeds upon roots beneath the ground.

FIG. 14.—Turnip Flea-beetle, larva and pupa.

"The pupa is naked, white, and transforms in a little earthern cocoon, pressed and prepared by the larva, in the ground near its feeding-place. This period is short."

THE TURNIP-BUTTERFLY, *Pieris oleracea* (Harris).—Devouring the leaves of the turnip; a velvety dark-green caterpillar, changing to an unspotted white butterfly.

Though this butterfly is spread all over the northern portion of our continent from Maine to Utah, and is more abundant in Colorado and Utah (having probably recently been introduced there) than in the Eastern States, so far as my observations have extended, it is nowhere particularly distinctive. As I am somewhat dependent on my own observations regarding the transformations of this delicate-tinted butterfly, I extract the following notice of it from my Guide to the Study of Insects: "We have found the larvæ of this species on turnip-leaves in the middle of August at Chamberlain Farm, in northern Maine. They are of a dull green, and covered with dense hairs.

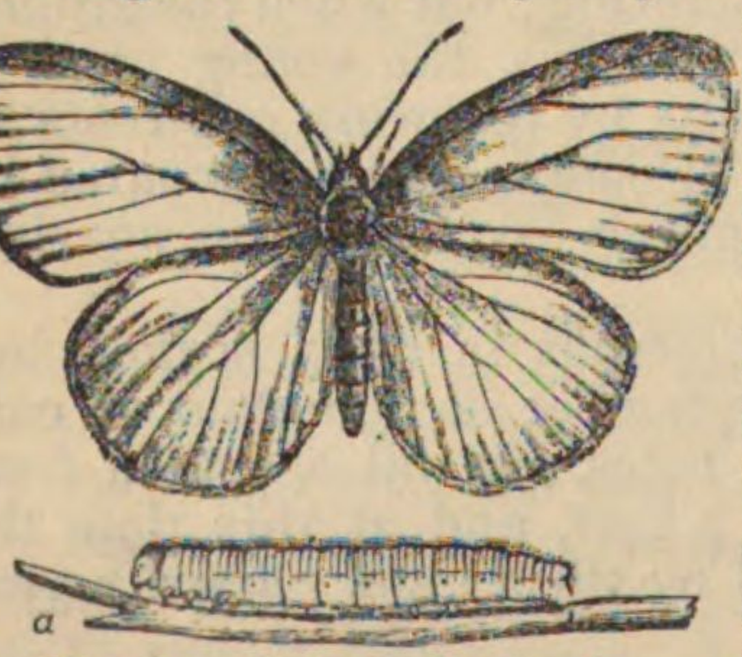

FIG. 15.—Turnip Butterfly and Caterpillar.

They suspend themselves by the tail and a transverse loop, and their chrysalids are angular at the sides and pointed at both ends (Harris). *Pieris oleracea* is white, with the wings dusky next the body. The tips of the fore wings are yellowish beneath and the hind wings are straw-colored beneath. The yellowish, pear-shaped, longitudinally-ribbed eggs are laid three or four on a single leaf. In a week or ten days this larvæ are hatched. They live three weeks before becoming full-fed. The chrysalis state lasts from ten to twelve days. There is an early (May) and a late summer (July) brood."

Remedies.—It should be borne in mind that the caterpillar feeds on the under side of the leaves, so that if they are turned over in June and again in August and carefully examined, the dark-green caterpillar, whose color blends with that of the turnip-leaf, can be picked off and trod under foot.

INSECTS INJURING THE CABBAGE.

THE EUROPEAN CABBAGE-BUTTERFLY, *Pieris rapæ* Schrank.—Feeding not only on the outer leaves, but boring into the heads in all directions; a green, velvety caterpillar with a yellowish stripe along the back and side, and turning into a white butterfly with four (male) or six (female) conspicuous black spots.

While the caterpillar of our native cabbage (and turnip) butterfly (*P. oleracea*) feeds on the outer leaves, the present species is much more destructive and difficult to destroy, from its habit of boring into the interior of the cabbage-head. It also devours the cauliflower and feeds on the mignonette.

It was introduced from Europe to Quebec about the year 1857, having been captured in 1859 by Mr. Bowles, of that city. It rapidly spread into New England along the different railroads leading in from Canada, and is now common about Boston and New York and southward to Philadelphia and Washington. During the year 1870 it did much damage in gardens in Monmouth County, New Jersey, as I am informed by Dr. S. Lockwood. About Quebec it annually destroys $250,000 worth of cabbages, according to the Abbé Provancher.

A correspondent of the American Agriculturist for November, 1870, states that "it is estimated that the loss from this insect will, in the vicinity of New York [city] alone, exceed half a million of dollars, and already the price of cabbages has advanced." He says that Mr. Quinn, the owner of a large plantation, "has found carbolic powder, superphosphate, and lime together to destroy them. The carbolic powder appears to be sawdust impregnated with carbolic acid. Salt has been recommended, but Mr. Quinn did not find dry salt efficacious, though lime has been reported by others as useful."

It is evident that in this newly-arrived insect we have another formidable pest added to our list of imported insects.

It is to the parasites of this butterfly that we are to look for the natural means of keeping this insect pest within bounds.

Mr. Curtis has described and figured several parasites of the three species of cabbage-butterflies found in England, and he shows how thoroughly they keep in check these troublesome worms. Certain minute ichneumon-flies (*Chalcids*) lay their eggs in those of the butterflies. Another chalcid fly (*Pteromalus brassicæ*) lays its eggs on the outside of the chrysalis of the white cabbage butterfly (*Pieris brassicæ*), and sometimes 200 or 300 of the little chalcid maggots have been found living riotously within a single chrysalis. They turn into minute brilliant flies, which multiply in excessive quantities. Mr. Curtis remarks that "some species of this extensive genus (*Pteromalus*), probably comprising

nearly 1,000 species (!), swarm even in our houses, especially in the country, where in October and November I have seen immense numbers inside of the windows, and I believe that they hibernate behind the shutters, in the curtains," etc.

Were it not for the native ichneumon parasite, (Fig. 16, *a*, male; *b*, female,) which has been found to prey upon it very extensively, the cultivation of the cabbage would have to be given up in some districts. This invaluable ichneumon is one of the chalcid family, and is the *Pteromalus puparum* of Linnæus. It is well known that the cabbage-caterpillar (*Pieris rapæ*) was introduced into this country about the year 1857. I had supposed that the parasite had perhaps been imported with its host, but now find that it is undoubtedly a native of this country as well as Europe. Having been favored by Mr. Francis Walker with specimens of both sexes from England, labeled by him *Pt. puparum*, I found that our specimens did not differ specificially. Further, Mr. Walker wrote me that there were specimens of the same species in the British Museum, taken in Hudson's Bay territory in 1844. During the past summer Mr. P. S. Sprague, sent me specimens which had been raised from the rape caterpillar in Vermont. Mr. J. A. Lintner has also published a note in the American Naturalist stating that he had reared this parasite from the same kind of caterpillar, and previously to this Mr. S. H. Scudder had received numerous specimens from Mr. A. G. T. Ritchie, of Montreal, Canada, who, if I understand his letter aright, first observed these chalcids upon the cabbage-leaves in July, 1870, when the caterpillars were abundant. On the 23d of August of the same year he had some of the parasites hatch out. To Mr. Ritchie, then, is due the credit of being the first to make known the history of this invaluable insect.

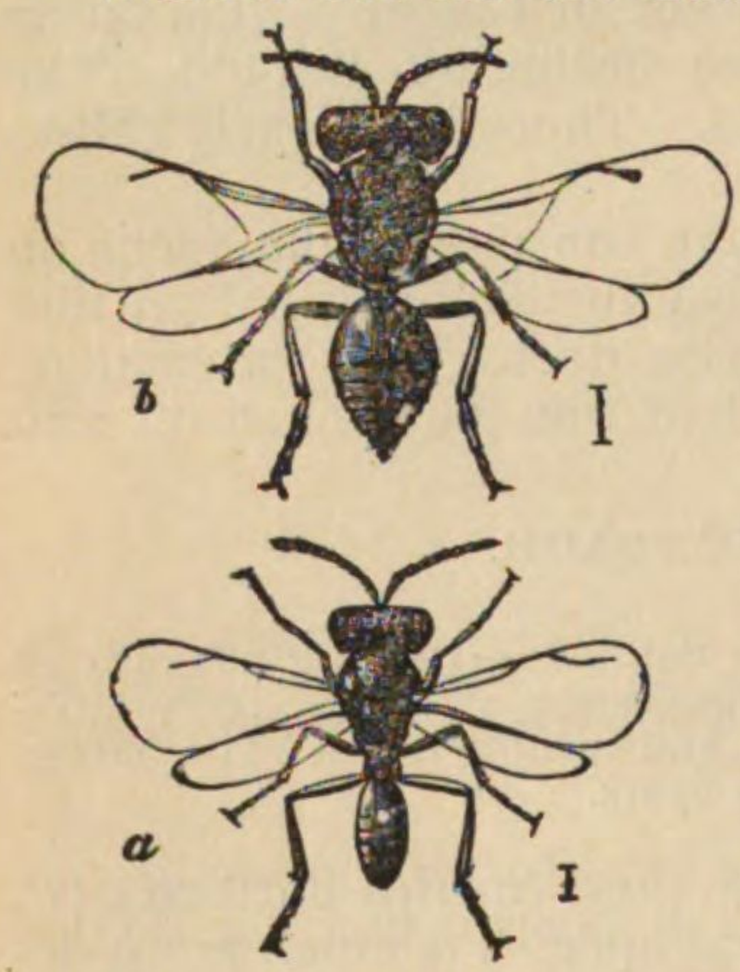

FIG. 16.—Parasite of the imported Cabbage Butterfly.

It seems that the parasite covers even a wider field than its host, and probably preys on our native cabbage-butterfly, the *Pieris oleracea*, as in Europe it preys on *Pieris brassicæ*, the caterpillar so destructive to the cabbage there.

Description.—The male of this *Pteromalus* is a beautiful pale-green fly, with the body finely punctured and emitting metallic tints; the abdomen, or hind body, is flat, in dried specimens with a deep crease along the middle of the upper side, and it is much lighter in color and with more decided metallic reflections than in the rest of the body. The antennæ are honey-yellow, with narrow black wings. The legs are pale honey-yellow. It is .08 inch to a tenth in length.

The body of the female, which would be thought at first to be an entirely different kind of insect, is much stouter, broader, with a broader oval abdomen, ending in a very short ovipositor, while the under side of the body near the base has a large conical projection. It is much duller green than the male, and the body is more coarsely punctured. The scutellum of the metathorax is regularly convex, not keeled, in both sexes. The antennæ are brown, and the legs brown, becoming pale toward the ends, the ends of the femora being pale; the tibiæ pale brown in the middle, much paler at each end, while the tarsi are whitish, though the tip of the last joint is dark. It is from a line to a line and a third in length. It differs from Harris's *Pteromalus vanessæ* in the little piece known as the scutellum of the metathorax being smooth, not keeled, and by its darker legs.

The larva is a little white maggot about a sixth (.17) of an inch in length. The body consists of thirteen segments, exclusive of the head, and is cylindrical, tapering rapidly toward the head, while the end of the body is acutely pointed. The chrysalis is whitish, the limbs being folded along the under side of the body, the

antennæ reaching to the end of the wings; the second pair of legs reaching half-way between the end of the wings and end of abdomen; while the tips of the third pair of feet reach half-way between the second pair of feet and the end of the abdomen. It is from a line to a line and a third in length.

In the middle of September Mr. F. W. Putnam handed me one hundred and ten chrysalids, all but two of which were infested by these parasites in both the larval and pupal states; while from other chrysalids the adult chalcid flies were emerging. They continued to emerge until late in the autumn. The infested chrysalids of the butterfly could be easily distinguished by the livid and otherwise discolored and diseased appearance of the body, while those unattacked had preserved the fresh color, and the tail moved about readily; the diseased ones becoming stiff and more or less dried. Mr. Putnam thinks that at least two-thirds of the chrysalids of this butterfly, hundreds of which had in the early autumn suspended themselves about his house and fences, had been attacked by these useful allies.

On opening the body of the infested chrysalids I found about thirty parasites in different stages of growth, in one case thirty two, in another only twelve. We can readily see how efficient these minute insects become in reducing the numbers of their hosts. A large proportion of the *Pteromalus* undoubtedly winter over in the body of the chrysalis, the adult insects appearing in the spring. In England Mr. Curtis found the fly in June, so that evidently there is an autumn and spring brood of flies.

Another parasite is the larva of a parasitic fly, *Tachina* (Fig. 17, enlarged three times), the adult form of which closely resembles the common house fly. It is a flattened, cylindrical maggot, both ends of the body rounded much alike. The mouth parts are partly aborted, there being only two retractile horny mandibles by which the fatty portions of its host is eaten.

FIG. 17.—Larva of Tachina.

Besides this large *Tachina* I found a minute fly in the same bottle with a number of the chrysalids of the butterfly, and am inclined to think that it may have lived parasitically in them, but would not be confident that it is so. It is a small black fly, about a line in length, and with dark wings.

The male butterfly (Fig. 18) is white, with the tips of the fore wings

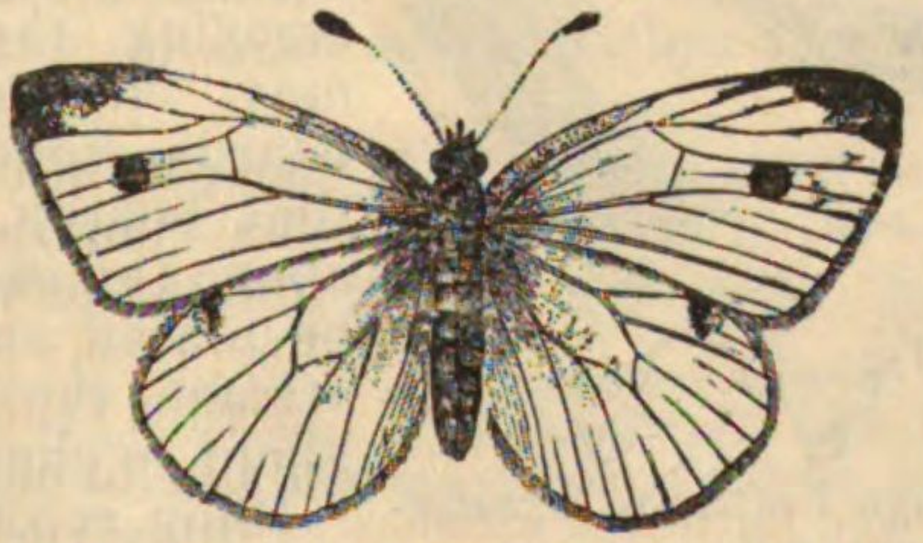

FIG. 18.—European Cabbage Butterfly, male.

black, dusted with white, while on the fore wings is a single, and in the female there are two large black spots, situated two-thirds of the distance from the base to the outer edge of the wing. It expands about two inches. The female lays her eggs singly on the under side of the leaves. The caterpillar (Fig. 20, *a*) is green, and so densely clothed with minute hairs as to be velvety; it has a yellowish stripe down the back and another along each side, the belly being of a paler, brighter green; it is often more than an inch long, and about as thick as a large

crow-quill. It changes in September, under some board or stone, to a chrysalis, suspended by a thread spun over the back as shown at Fig. 20, *b*. It is of a pale flesh-brown color, freckled with black. It winters in this state, the butterfly appearing in Massachusetts early in May.

The native cabbage-butterfly (*Pieris protodice*, Figs. 21–23) is but slightly injurious to the cabbage in the Southern and Western States.

Remedies.—It does not appear to have been very destructive in Europe, but, like other introduced species, it suddenly becomes a fearful scourge in a new country. The best remedies are evidently hand-picking, when the caterpillars can be seen, and the capture of the butterflies by means of a light gauze-net mounted on a wire ring a foot in diameter, and attached to a short pole. Affected cabbage-heads should be carefully examined, and if much infested by worms, be burned; for, if they are suffered to lie about the garden after being pulled up, the caterpillars will attack the other plants.

FIG. 20.—European Cabbage Butterfly. *a*, caterpillar, *b*, chrysalis.

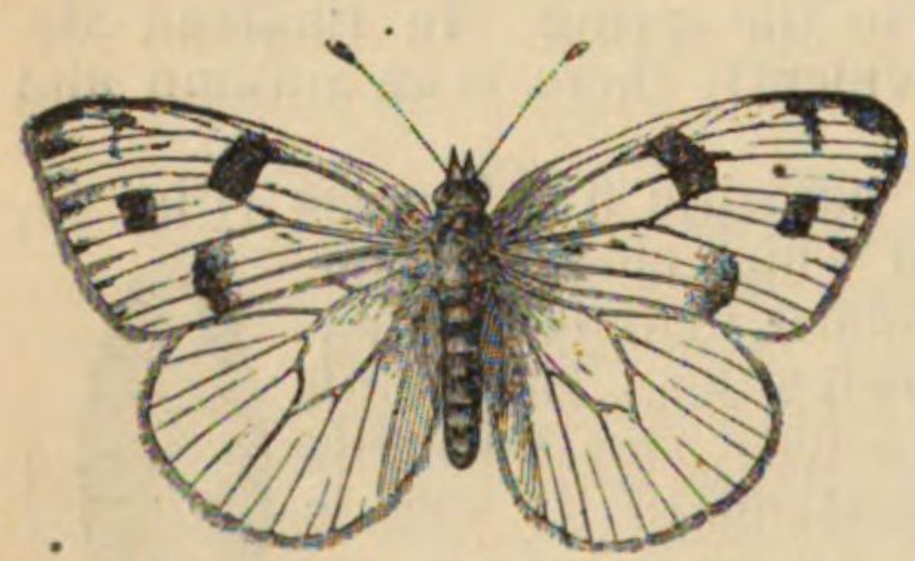

FIG. 21.—Native Cabbage Butterfly, male.

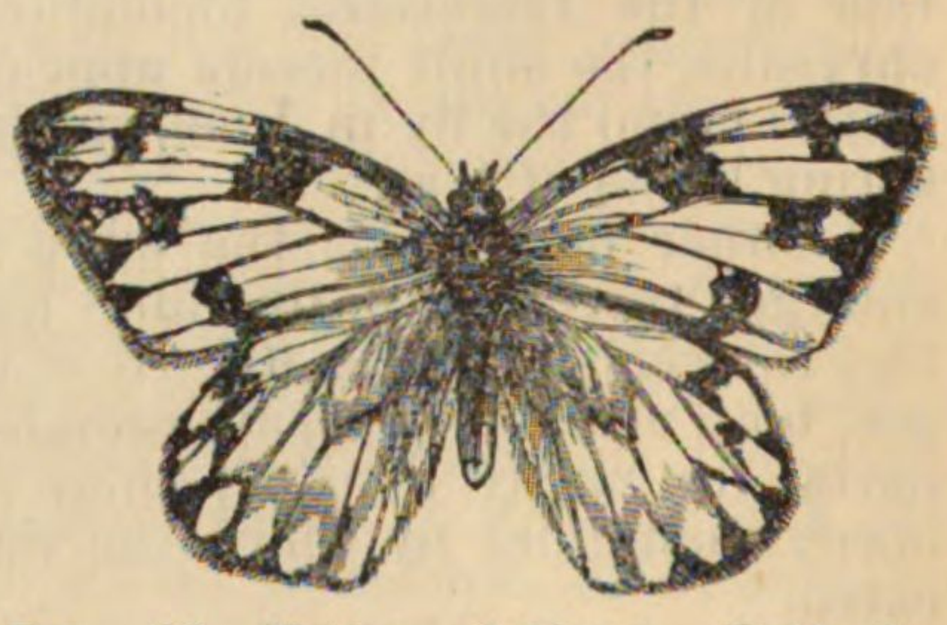

FIG. 22.—Native Cabbage Butterfly, female.

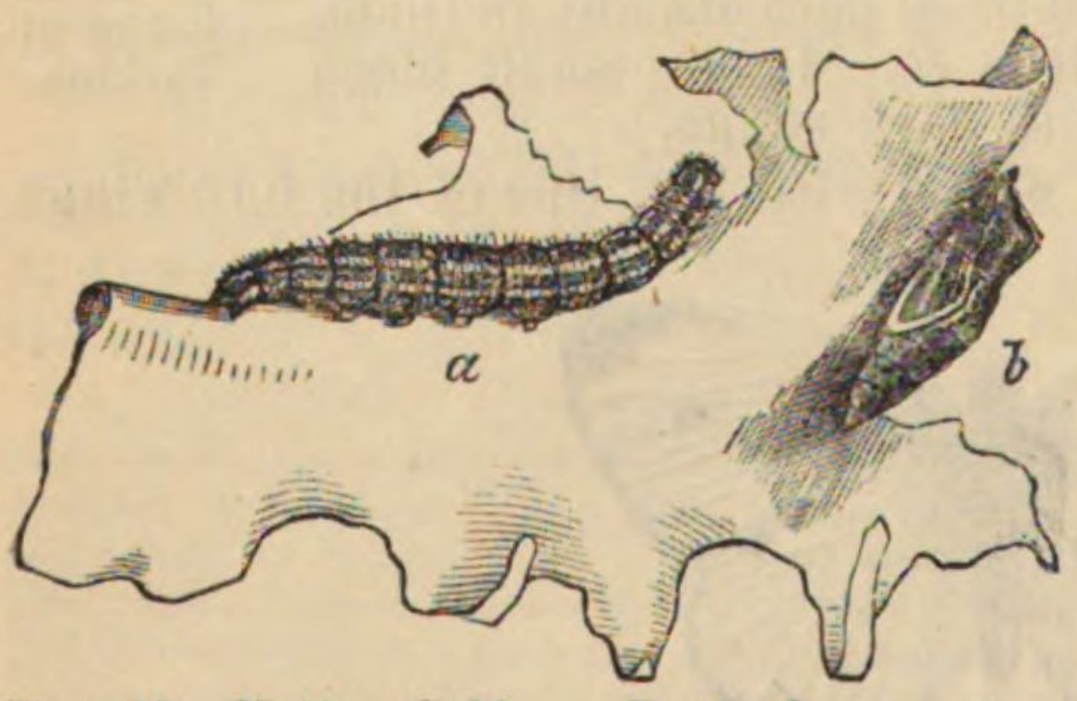

FIG. 23.—Native Cabbage Butterfly. *a*, caterpillar, *b*, chrysalis.

Mr. C. S. Minot, in an article entitled "Cabbage-butterflies," in the American Entomologist, vol. ii, strongly recommends destroying the chrysalis, which may be found under chips, boards, stones, etc., and advises that boards, raised two inches above the surface of the ground, be placed among the plants to attract the caterpillars when about to change to a chrysalis.

Riley recommends drenching the plants with a wash of cresylic soap, for this and other noxious cabbage-insects. As those chrysalids which are infested by the chalcid flies are readily distinguished from the healthy ones by their livid and diseased appearance, they can be selected and preserved or left alone, and thus the parasites can be bred.

The Toronto Globe recommends hot water to be applied to cabbages that are infested with the *Pieris rapæ*, sprinkled on from a fine rose watering-can. The water may be boiling-hot when put into the can, but it will not be too hot when it reaches the leaves. The thick fleshy nature

of the leaves enables them to withstand considerable heat with very little injury. The sacrifice of a few heads of cabbage will soon teach an experimenter how far he can go with the hot water. A Rural Home correspondent speaks also from his own experience and says: "I heat water to nearly a boiling-heat, and put it on with a common watering-pot, with the sprinkler removed. If it is very hot it will color some of the leaves, but it does not seem to hurt the cabbage in the least. This will kill the young worms and nearly all the old ones. There will sometimes be a few that do not get touched with the water. These can be picked off with a small pair of pincers. If there are not a great many the last remedy will do."

THE EUROPEAN CABBAGE WEB-MOTH, *Plutella xylostella* (Linnæus).—Small green caterpillars, feeding on the under side of the outer leaves, and spinning web-like cocoons in folds in the leaves; changing to a small moth somewhat like a clothes-moth.

My attention was first called to this moth, now almost cosmopolitan in its distribution, in September and October, 1870, at the Agricultural College at Amherst, Mass. The little green caterpillars were quite abundant on the under side of the outer leaves of the cabbages on the college-farm, and their web-like, delicate cocoons were found attached to the leaf in depressions or folds. Afterward a correspondent in Michigan sent me specimens of the worm, the cocoon, and moth, stating that it was doing great damage to the cabbages there. The season at Amherst, as all over New England in 1870, was very warm and unusually dry, which accounts for the unusual increase in this insect.

This insect, well known in Europe, whence it has been carried all over the civilized world, was first noticed in this country by Dr. Fitch in 1855, who gives an account of it in his "First and Second Reports," etc., having observed it in Illinois, but not in New York. He called it *Ceros-toma brassicella*, but it is undoubtedly the well-known European *Plutella xyllostella* Linn. Though the insect has been observed in this country only late in the autumn when the cabbages have headed, yet these worms, as Dr. Fitch suggests, probably belong to a second brood. Stainton, in his "Manual of British Butterflies and Moths," states that the moths fly in May and August, while the caterpillars appear in June, July, and a second brood again in September. Dr. Fitch suspects that the first brood of caterpillars may feed on the young cabbage-plants in early summer, and thus do more mischief than in the autumn when the heads are fully formed.

Mr. C. A. Putnam, of Salem, brought me specimens found on the cauliflower. On November 15 it pupated in a thin cocoon consisting of a single layer of silk forming a very open web.

Description.—The *caterpillar* is a little pale-green worm, with small, stiff, dark hairs scattered over the body; it is a quarter of an inch long. When about to transform it spins a beautiful open net-work of silk as a cocoon, open at one end, of white silken threads; it is a third of an inch long.

Pupa with a long, broad, white dorsal band, and a broad, lateral band, widening before and inclosing three oblique dark stripes, the lower of which is formed by the antennæ. In a more mature chrysalis the white bands become narrower, and the dark portions darker.

The moth is pale gray, with the head, palpi, and antennæ white, but the latter are ringed alternately with white and gray on the outer half. The rest of the body is gray, except on the under side, and on the middle of the thorax, where there is a broad, white, longitudinal band, which, when the wings are folded, is continuous with the white band along the inner side of the wings. The two front pair of legs are gray, with the tarsal joints ringed narrowly with white; the hind legs are whitish and hairy. The fore wings are gray, with a conspicuous broad, longitudinal, white band along the inner edge, and extending to the outer third of the wing; this band sends out three teeth

toward the middle of the wing, the third tooth being at the end of the band. There is a row of dark dots along the outer edge of the stripe; a row of blackish dots along a pale shade just outside of the front edge of the wing, and two diverging rows of blackish dots diverging upon the tip or apex of the wing. The fringe is marked with a few dark spots. The middle of the wing next the white band is darker than the front edge, while a faint yellowish shade runs along the middle of the outer half of the wing toward the tip, inclosing a few black dots. It expands a little over half an inch.

Remedies.—Should young plants be attacked by the worms, the best remedy would be to shower them with soap-suds. For the autumnal brood of worms the plants should be plentifully showered; and if this is not efficacious, the worms, and the cocoons especially, should be picked off by hand.

THE CABBAGE PLUSIA, *Plusia brassicæ* Riley. (Fig. 25.)—In August and September, gnawing large, irregular holes in the leaves; a rather large, pale-green caterpillar, marked with still paler, more opaque lines, and with three pairs of abdominal feet, being a semilooper, and changing to a grayish-brown moth, whose wings are marked with a distinct silver interrogation mark.

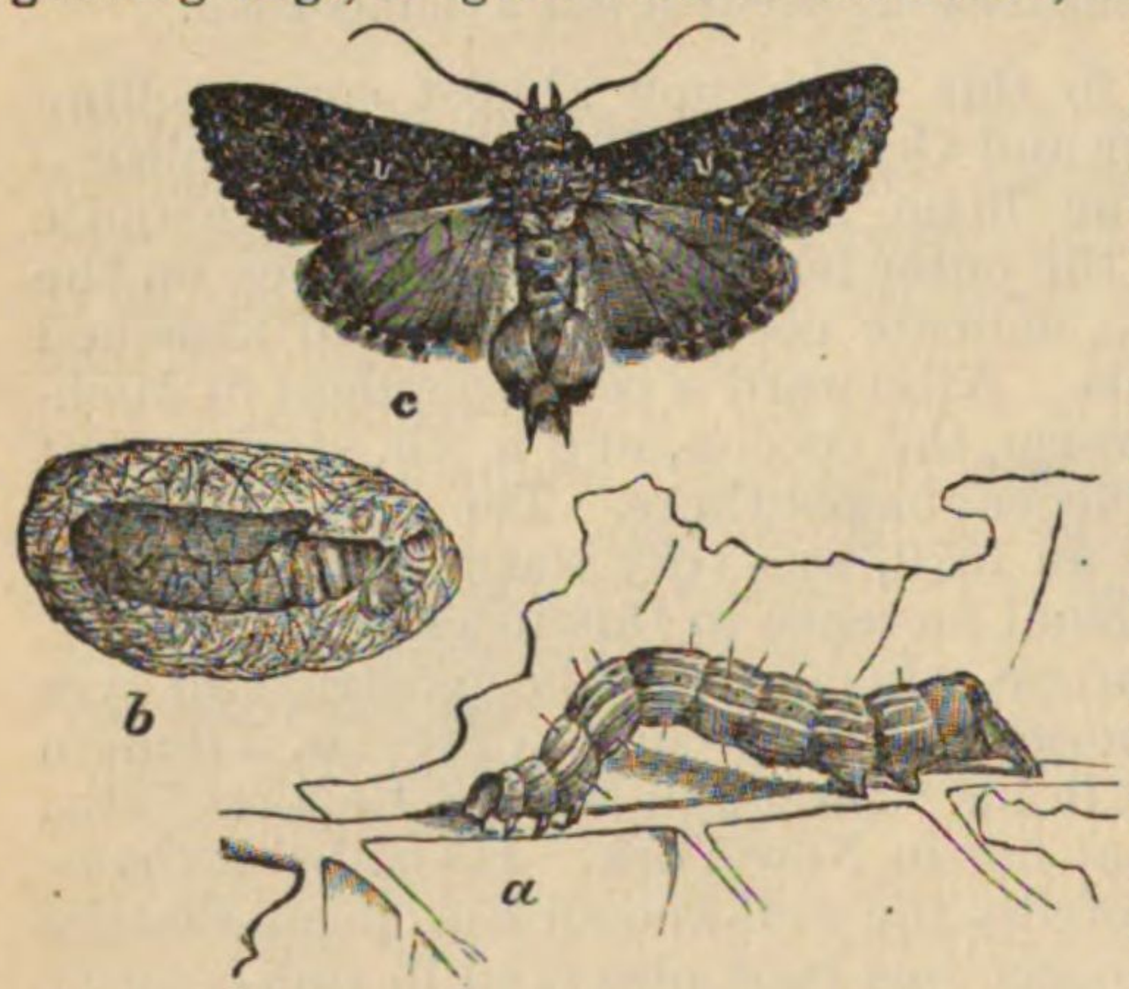

FIG. 25.—Cabbage Plusia. *a*, caterpillar, *b*, pupa in its cocoon, *c*, moth. After Riley.

This caterpillar has been found by Mr. Riley to do considerable mischief in Missouri. I quote his account of its appearance and habits:

"In the month of August and September, the larvæ may be found quite abundant on this plant, gnawing large, irregular holes in the leaves. It is a pale-green translucent worm, marked longitudinally with still paler, more opaque lines, and, like all the known larvæ of the family to which it belongs, it has but two pair of abdominal prolegs, the two anterior segments, which are usually furnished with such legs in ordinary caterpillars, not having the slightest trace of any. Consequently, they have to loop the body in marching, as represented in the figure, and are true 'span-worms.' Their bodies are very soft and tender, and as they live exposed on the outside of the plants, and often rest motionless, with the body arched, for hours at a time, they are espied and devoured by many of their enemies, such as birds, toads, &c: They are also subject to the attacks of at least two parasites, and die very often from disease, especially in wet weather; so that they are never likely to increase quite as badly as the butterflies just now described.

"When full-grown, this worm weaves a very thin, loose, white cocoon, sometimes between the leaves of the plant on which it fed, but more often in some more sheltered situation, and changes to a chrysalis, which varies from a pale yellowish-green to brown, and has a considerable protuberance at the end of the wing and leg cases, caused by the long proboscis of the inclosed moth being bent back at that point. This chrysalis is soft, the skin being very thin, and it is furnished at the extremity with an obtuse roughened projection which emits two converging points, and several short, curled bristles, by the aid of which it is enabled to cling to its cocoon.

"The moth is of a dark smoky-gray, inclining to brown, variegated with light grayish-brown, and marked in the middle of each front wing

with a small oval spot and a somewhat U-shaped silvery-white mark, as in the figure. The male is easily distinguished from the female by a large tuft of golden hairs, covering a few black ones, which springs from each side of his abdomen toward the tip.

"The suggestions given for destroying the larvæ of the cabbage-butterflies apply equally well to those of this cabbage plusia, and drenchings with a cresylic wash will be found even more effectual, as the worms drop to the ground with the slightest jar."

THE ZEBRA CATERPILLAR, *Mamestra picta* Harris.—Feeding on the leaves of turnips and cabbages, and other garden vegetables; a long, cylindrical caterpillar with a red head, with a broad band along the side, composed of numerous transverse, short, black lines, like Runic characters upon a white ground, changing to a reddish-brown dark moth.

While this pretty caterpillar, than which none are more curiously and gaily decked, is ordinarily harmless, feeding indiscriminately on different vegetables, it has been twice found in Massachusetts, within my own knowledge, to be extremely destructive to the ruta-baga turnip, nearly destroying entire beds. In the summer of 1876, up to the middle of September, it was very abundant and eat off the tops of a good many ruta-bagas on the farm of the Massachusetts Agricultural College, at Amherst, Mass. I am also told that it sometimes attacks the roots. Harris says that it "is often found to be injurious to cabbages, cauliflowers, spinach, beets, and other garden vegetables with succulent leaves." In the New England States the caterpillars are usually seen in August and September. Harris remarks that early in October it leaves off eating, goes into the ground, changes to a shining-brown chrysalis, and is transformed to a moth about the first of June. It is probable that there are two broods of this kind of caterpillar every summer in some, if not all, parts of this country; for Dr. Melsheimer informs me that it appears in Pennsylvania in June, goes into the ground, and is changed to a chrysalis toward the end of June or the beginning of July, and comes forth in the moth state near the end of August." In Missouri, according to Riley, early in June the young worms, which are first almost black, though they soon become pale and green, may be found in dense clusters on these plants, for they are at that time gregarious. As they grow older they disperse and are not so easily found, and in about four weeks from the time of hatching they come to their full growth. * * * * It changes to chrysalis within a rude cocoon, formed just under the surface of the ground by interweaving a few grains of sand, or a few particles of whatever soil it happens on, with silken threads. * * * * There are two broods of this insect each year, the second brood of worms appearing in the latitude of Saint Louis from the middle of August along into October, and in all probability passing the winter in the chrysalis state, though a few may issue in the fall and hibernate as moths, or may even hibernate as worms; for Mr. J. H. Parsons, of New York, found that some of the worms which were on his ruta-baga leaves stood a frost hard enough to freeze potatoes in the hill without being killed. I have noticed that the spring brood confines itself more especially to young cruciferous plants, such as cabbages, beets, spinach, etc., but have found the fall brood collecting in hundreds on the heads and flower-buds of asters, on the white berry or snow-berry (*Symphoricarpus racemosus*), on different kinds of honeysuckle, on mignonette, and on asparagus; they are also said to occur on the flowers of clover, and are quite partial to the common lamb's quarter or goosefoot (*Chenopodium album*). On account of their gregarious habit when young, they are very easily destroyed at this stage of growth.

Description.—I have observed this caterpillar in different stages at Amherst, Mass., in September, 1876, when it was ravaging the ruta-bagas. *In the young, before the first molt*, the head is as wide as the body, pale greenish, while the body is pale greenish, with a double, dark, livid, dorsal stripe divided by a pale median line and three lateral dark stripes, the uppermost of which is the narrower; five pairs of abdominal feet, the first pair one-half as large as the fourth pair. The body is tuberculated, being much smoother in the fully-grown larva. Length, a little over a line. *After the first molt*, when the worm is a little over three lines in length, the colors are much as in the fully-fed larva, being deep yellow, with a broad, black, dorsal band, sometimes entire and sometimes divided by a median pale line. A lateral area is marbled with transverse, short, black and white lines, and with a row of conspicuous black spots. A row of dark spots down on the sides. Head reddish testaceous; abdominal feet reddish. *After the third molt*, when the caterpillar is one inch long (observed September 16,) the markings are nearly the same as the mature caterpillar. The fully-fed larva is unusually long, cylindrical, about two inches in length, the body tapering slightly toward the head, which is orange-red. A broad, dorsal, dark line, edged with yellow, with two white dots in the middle of each ring. A broad, lateral, white band, traversed by rune-like black lines, inclosing a line of large black dots, one in the lower edge of each ring. A lateral line of yellow, below which is a marbled line of white and black dots. Legs, both thoracic and abdominal, and under side of the body, tinged with orange. The *moth* is clear reddish-brown, with a purplish tint, on the head, thorax, and fore wings, while the hind wings are whitish, contrasting strongly with the rest of the body. The hind body, or abdomen, is dull ash-gray. Fore wings with a conspicuous, light, round spot in the middle of the ring, beyond which is a kidney-shaped light spot, containing a dark ring. The veins are darker than the rest of the wing, and firmly spotted with light scales. It expands a little over an inch and a half.

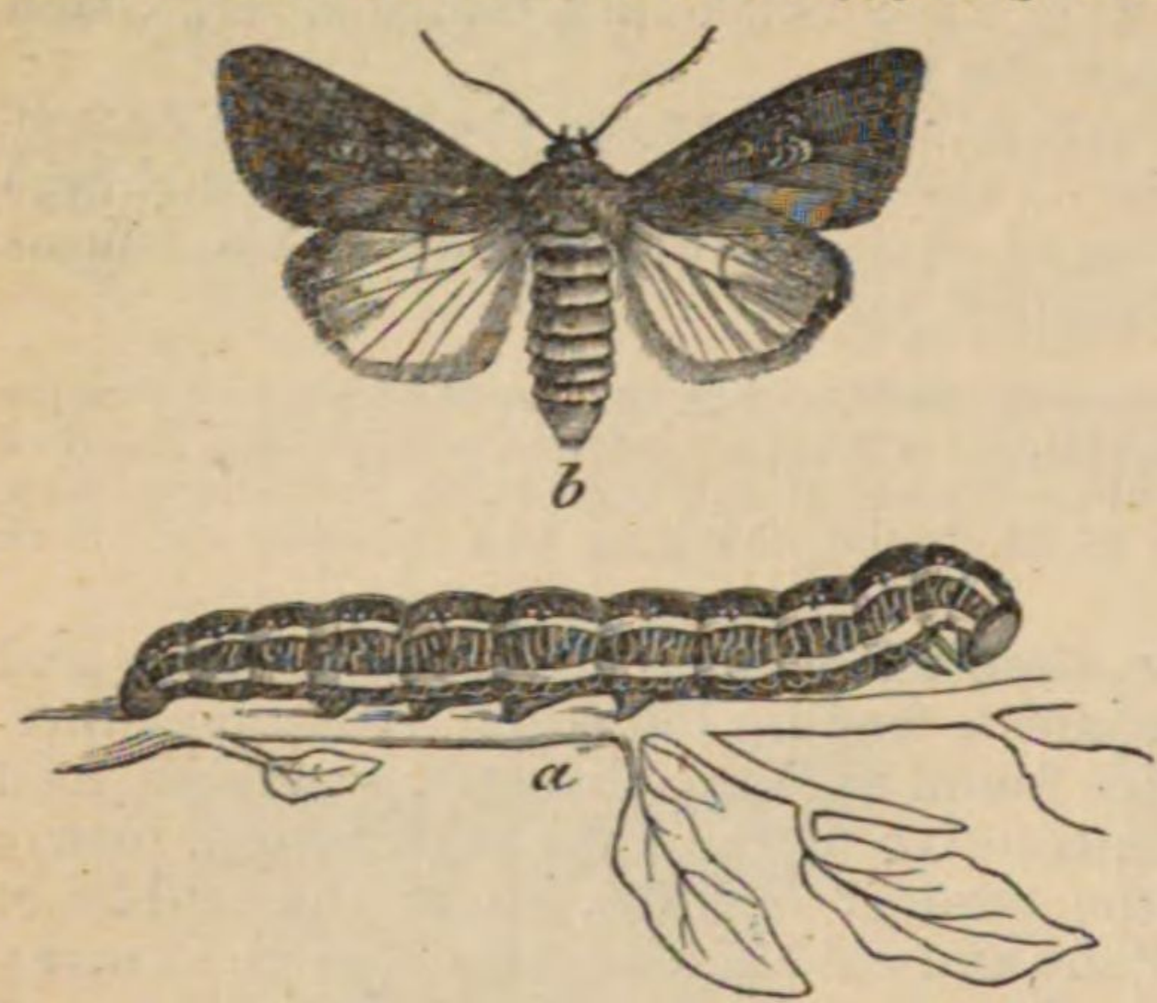

FIG. 26.—Painted Mamestro. *a*, larva. After Riley.

THE CABBAGE-PLANT LOUSE, *Aphis brassicæ* Linn.—Sometimes gathering in immense numbers on the outer leaves; a woolly, greenish louse, the winged ones spotted with black, disfiguring the heads.

This insect is called by Curtis, in his "Farm Insects," the cabbage and Swedish turnip-leaf plant louse; the species that I have observed in Maine and Massachusetts is without much doubt the same as the European.

It has not yet been known to be specially injurious in the New England States, though liable at any year to be so. In New York, however, in one case it has proved very destructive, as in the following case cited by Dr. Fitch: "J. L. Edgerton, of Waverly, N. Y., states (Country Gentleman, July, 1857, p. 80) that his patch of cabbages the year before, comprising three hundred and fifty large, thrifty plants, were attacked by lice just as they were beginning to head, and in three weeks every plant was covered by these vermin and he lost the whole, neither ashes nor salt having any effect upon them." From July, says Fitch, to the close of the season it may be found on the plants, either solitary or in clusters, inhabiting for the most part the upper sides of the inner leaves and the under sides of the outer ones. It is in the former case that it is most pernicious by sucking the juices from and weakening this part, whereby it heads tardily and imperfectly, or, if thel ice are numerous, no head is formed and the plant is worthless. The ruta-baga, or Swedish turnip, is also in this country, says Dr. Fitch, subject to its attacks, "the under side of the

curled leaves being sometimes densely covered with them, of all sizes." Dr. Fitch shows that it was known in this country as early as 1791.

Description.—These *winged females* measure 0.075 in length to the tip of the abdomen, and 0.14 to the end of the closed wings, and their width from tip to tip of the extended wings is 0.18. They are of a dull greenish color, varying to pale, dull yellowish, and largely varied with black. The head, neck, and fore body on its upper side are black and shining. The horns, or antennæ, are two-thirds the length of the body, more slender toward their tips, and black. On the neck one or two pale yellowish bands are sometimes perceptible. The hind body is usually pale green, with dark-green or black bands on the back, which are often narrowed or somewhat broken asunder in the middle, and have one or two dots or small spots at their outer ends in a longitudinal row; the honey-tubes scarcely equal the distance to the tip and are black, with their bases pale yellowish. The legs are black; with the basal half of the shanks and of the thighs pale yellowish. The wings are hyaline and iridescent, their stigma pale greenish, and their veins black or dark brown. The distance between the first and second veins at their base is a little more than half that between them at their tips; third vein farther from the second at the tip than at the base, and a little nearer to the second at the base than the second is to the first; first fork a little nearer to the second fork than to the third vein, and a little nearer to the third vein than the third is to the second; second fork very little nearer to the fourth vein than to the first fork; fourth vein slightly curved, and very little nearer to the second fork than to the tip of the rib-vein.

Remedies.—When specially destructive, Dr. Fitch recommends driving short stakes and spreading a sheet, a large piece of canvas, or old carpeting over as many plants as the cloth will cover, and fumigating with tobacco until the space is filled with smoke. The plants may then be cleaned with water from a watering-pot. The remainder of the cabbage-patch can be treated in the same way. Soap-suds will only kill the young lice, leaving the old ones unhurt. "Watering the plants with equal parts of tobacco-water and lime-water is said to be the best mode of destroying the *Aphides* in gardens; and if plants be washed with tobacco-water alone—about half a pound of tobacco to a half-gallon of hot water—it will kill the *Aphides;* and if applied warm, it will kill them the sooner."—(Fitch.)

THE COMMON GARDEN PLANT-BUG, *Lygus lineolaris* (Beauvois); *Capsus lineolaris* Beauvois. (Plate LXVI, Fig. 14.)—Pucturing with its beak the cabbage and all sorts of succulent garden-vegetables and the shoots of shrubs and fruit-trees, causing them to wither and shrivel; flying from April to October, and clustering on the flowers of the cabbage in summer.

Though this plant-bug is indiscriminate in its attacks upon all sorts of garden-vegetables, more complaints have been made of its injuries to the cabbage than any other vegetable. It is especially abundant during warm, dry seasons. On examining the insect, a long, slender beak will be found resting on the breast; this it inserts in the leaf or shoot and sucks the sap. Frequent repetitions by great numbers of these bugs cause the leaves to wilt and die, and as they abound during a season of drought when the plants are weak, they are at times very destructive. Mr. Riley has found that it injures the tender shoots of pear-trees, while it has long been known to attack asters, dahlias, marigolds, balsams, and other flowers. The larvæ appear in the spring and acquire the rudiments of wings late in May or early in June in New York, becoming fully fledged by the 10th of June, according to Fitch. Mr. Uhler says that it is almost as common in the cultivated districts of Colorado as it is in the Eastern United States. I have found it to be common in Colorado and Utah. For remedies and other facts see page .

THE HARLEQUIN CABBAGE-BUG, *Murgantia histrionica* (Hahn).—Destroying, in the Southern States, by its punctures, cabbages, turnips, radishes, mustard, and other cruciferous plants; a bright black and orange-colored bug.

This pretty bug has been found to be very destructive in Texas by

Dr. G. Lincecum, who has given in the Practical Entomologist (vol. i, p. 110) the following account of its habits:

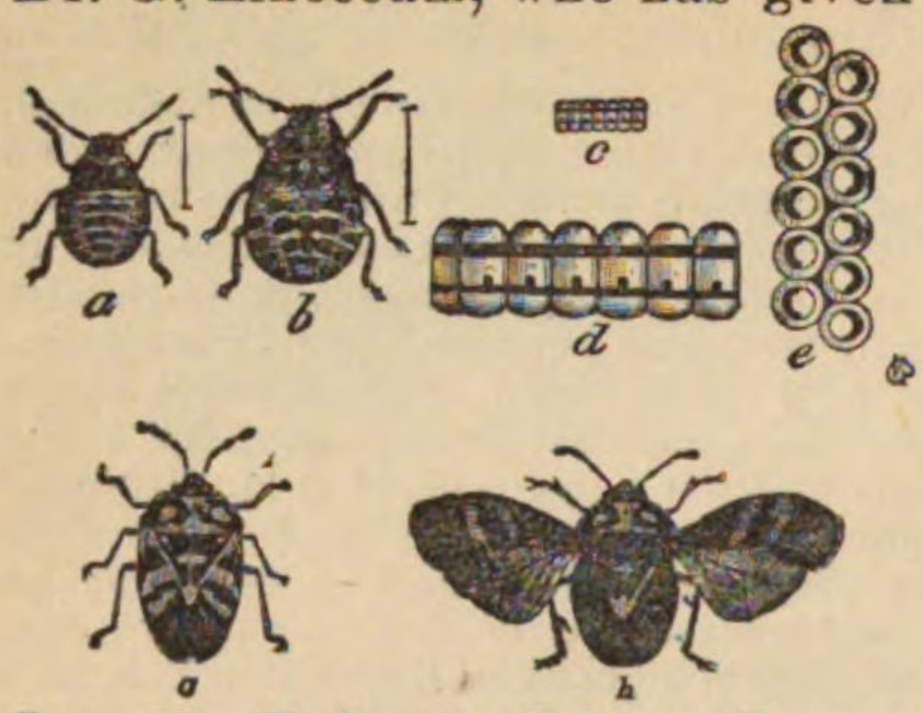

FIG. 27.—Harlequin Cabbage-Bug. *a*, larva; *b*, pupa; *c*, *d*, *e*, eggs, natural size and magnified; *g*, *h*, adult. After Riley.

"The year before last they got into my garden and utterly destroyed my cabbage, radishes, mustard, seed-turnips, and every other cruciform plant. Last year I did not set any of that order of plants in my garden. But the present year, thinking that the bugs had probably left the premises, I planted my garden with radishes, mustard, and a variety of cabbages. By the 1st of April the mustard and radishes were large enough for use, and I discovered that the insect had commenced on them. I began picking them off by hand and tramping them under foot. By that means I have preserved my four hundred and thirty-four cabbages, but I have visited every one of them daily now for four months, finding on them from thirty-four to sixty full-grown insects every day, some coupled, and some in the act of depositing their eggs. Although many have been hatched in my garden the present season, I have suffered none to come to maturity, and the daily supplies of grown insects that I have been blessed with are immigrants from some other garden.

"The perfect insect lives through the winter, and is ready to deposit its eggs as early as the 13th of March, or sooner, if it finds any cruciform plant large enough. They set their eggs on end in two rows, cemented together, mostly on the under side of the leaf, and generally from eleven to twelve in number. In about six days in April—four days in July—there hatches out from these eggs a brood of larvæ resembling the perfect insect, except in having no wings. This brood immediately begins the work of destruction by piercing and sucking the life-sap from the leaves; and in twelve days they have matured. They are timid, and will run off and hide behind the first leaf, stem, or any part of the plant that will answer the purpose. The leaf that they puncture immediately wilts, like the effects of poison, and soon withers. Half a dozen grown insects will kill a cabbage in a day. They continue through the summer, and sufficient perfect insects survive the winter to insure a full crop of them for the coming season. * * * * I have as yet found no way to get clear of them but to pick them off by hand."

It has spread northward from Texas into Missouri, appearing there, according to Riley, in 1870. Mr. Uhler (List of Hemiptera, p. 24) says that it inhabits Guatemala, Mexico, Texas, Arizona, Indian Territory, California, Nevada, Colorado, and from Delaware to Florida and Louisiana. "In the Atlantic region," he adds, "this species seems to be steadily but slowly advancing northward. Its introduction into Maryland has been effected since the late war, and now it is known as far north as the vicinity of the Pennsylvania boundary-line in Delaware. In the Mississippi Valley it appears to be equally common, particularly in the States of Illinois and Missouri." I found it to be not uncommon at Golden, Colo., in the summer of 1875, and it will probably be destructive there soon.

Description.—"The larva is of a uniform pale-greenish color, marked with polished black. The pupa differs from it only in some of the pale marks inclining to orange, and in the possession of conspicuous wing-pads; and they both differ from the mature

bug, not only in the non-possession of wings, but in their antennæ being but four instead of five-jointed, as they afterward become." The mature bug is prettily marked with polished orange and blue-black, the relative proportion of the two colors being very variable and the orange inclining either to yellow or red (Riley). Uhler says that various patterns of markings and colors, ranging from yellow to steel-blue, are conspicuously exhibited in this pretty but unstable and pernicious insect.

Remedy.—The best and surest, though most costly, remedy is hand-picking.

THE COLORADO GREEN FLEA-BEETLE, *Orchestris albionica* Le Conte.—Very abundant in Colorado at different elevations, eating holes in the leaves of cabbages and radishes, etc.; a small green flea-beetle, about one-tenth of a line in length.

This little flea-beetle is very abundant in Colorado at all elevations, and is destined to become a great plague. At Denver it was very abundant in June and July on cruciferous plants, especially the cabbage and radish, eating holes in the leaves. At Golden it was extremely abundant on young cabbage and radishes. At Idaho it was abundant on young turnips and potatoes, eating holes in the leaves. At Manitou these little beetles swarmed on beds of radishes and cabbages; the plants were small, just coming up, and these little pests were eating them up. Multitudes of them were found on the summit of Pike's Peak, on the grass and Alpine flowers, among the patches of snow, having probably been borne up from the plains and parks below by currents of air. Its habits are probably nearly identical with those of the turnip flea-beetle, to the account of which the reader is referred. The larva is to be looked for in the roots of the plants on which it feeds.

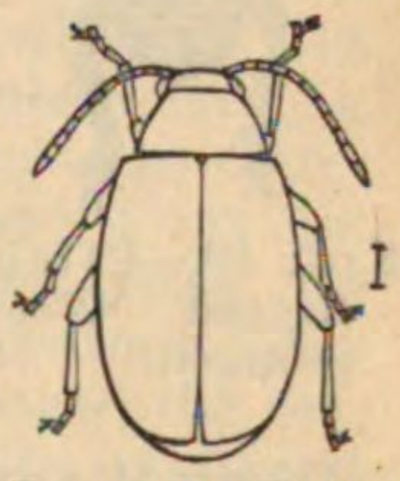

FIG. 28.—Colorado green Flea-Beetle.

Description.—It is a very small, green beetle, not quite one line in length; uniformly deep, shining olive-green. The surface of the body, especially the wing-covers, is coarsely punctured with little pits. Antennæ pubescent, dark, with the third, fourth, and fifth joints reddish-brown. Legs concolorous with the body; tarsi with a brownish tinge.

Remedies.—The use of Paris green on beds of young plants, and dusting ashes, or air-slacked lime over them, together with the planting of abundant seed.

THE PITCHY-LEGGED WEEVIL, *Otiorhynchus picipes* (Fabricius).—Damaging young cabbages, kale, broccoli, and other garden-vegetables; a pitchy-brown weevil, a quarter of an inch in length.

A weevil has for several years been not uncommon in Essex County, Massachusetts, which in England, from which it has been imported, is often, as Mr. Curtis says, "a dreadful pest in gardens, committing sad ravages on vines in hot-houses and on wall-fruit, during the night, when they emerge from their hiding-places in old walls, from under the bark, and clods of earth, to revel upon the branches of the new wood in April, or to feed upon the young shoots, which soon become black. They likewise injure raspberry plants in spring, by eating through the flowering stems and leaves, and they nibble off the bark, and eat out the buds of apple and pear trees as early as February or March." But they are said by Curtis to do still more damage to pease, turnips, and young winter-plants, as savoy, kale, broccoli, etc.

I have detected this weevil on the beach-pea during the last week in July at Salem, Mass., and it is not uncommon in gardens, and even, if I am not mistaken as to the identity of the insect, will enter ferneries

and nibble the ferns and make considerable havoc among the plants before its presence is suspected.

On July 16 I found one in a thin silken semi-transparent cocoon attached to a leaf of *Lathyrus maritimus;* the cocoon was large and full, being nearly half an inch long, cylindrical, both ends being rounded alike.

FIG. 29.—Pitchy-Legged Weevil, enlarged.

Description.—This insect (Fig. 29, enlarged) is pitchy brown, and covered with microscopic, pale scales, resembling a scallop-shell, being marked with a few prominent ribs. Indeed, many of the weevils seem to be provided with scales like those of butterflies, Poduras, and a few other insects. The beak, so short and slender in the radish-weevil, is here broad and short, square at the end, from which the elbowed reddish-brown antennæ arise. The head is a little darker than the rest of the body, and is coarsely punctured. The prothorax is coarsely granulated, the granulations being arranged in irregular rows. The wing-covers are adorned with about eleven high, rounded, longitudinal ridges on each cover, and with coarse punctures along the furrows between them. There are also about twenty rows of pale dots along the wing-covers, consisting of scales. The legs, including the claws, are rather paler than the rest of the body. The body is also covered with scattered pale hairs bent down on the surface, especially on the top of the head; these hairs remain after the scales are rubbed off. It is a quarter of an inch in length.

WIRE-WORMS AND CUT-WORMS.—Larvæ of various snapping-beetles, *Elater*, *Agrotis*, etc.—Although these insects have been fully described among those preying on wheat, corn, and grass, they are very destructive to young cabbages and allied garden-plants. Wire-worms feed on the roots, and sometimes destroy the whole crop in Kentucky. In England wire-worms are destroyed for many successive years by sowing salt over the surface of the ground at the rate of six bushels per acre just as the small grain is coming up.

Cut-worms are more difficult to contend with than wire-worms. They are active at night, hiding by day in the soil around the roots of the plants they infest. It would be well, therefore, to examine the soil around the young cabbage-plants, or to inclose the plants in tubes of stout paper to prevent the attacks of the worm.

As a remedy for wire-worms, J. H. Charnock, of Canada, advised the use of rape-cake. "The remedy consists," says Mr. Riley, "in applying 3 cwt. per acre of rape-cake broken into small lumps, and not crushed into dust. It is spread on the land and plowed in before sowing the seed. The worms are said to be so fond of it that they leave all other kinds of food, while the cake is said to act upon them as a vermifuge and to kill them, as they are found in it afterward in all stages, 'from repletion to death and decay.' Rape-cake is extensively used in England as a fertilizer, and I have not the least doubt but that it attracts the wire-worms, and may be used as a trap for this purpose like sliced potatoes, etc."

Riley questions whether it is so efficacious as has been claimed, but considers that it "is, however, well worthy of further trial, for even if, as I suspect, it does not kill, it has the advantage over the other substances to be strewn as traps and then collected, in that it at the same time acts as a fertilizer. Where it can be safely done, rape-cake as well as sliced potatoes, turnips, etc., that can be used as baits for these insects, might be poisoned with Paris green, and the necessity of collecting the worms to destroy them thus avoided. I know of nothing manufactured in this country that has the character of rape-cake, or could take its place."

THE FLATTENED MILLEPEDE, *Polydesmus canadensis* Newport.—"Eating the roots of plants and other tender vegetations, and probably causing the anbury (club-root) disease in cabbages; small, slender, white and brown worms, from one to five-tenths of an inch long, flattened upon the back, and with numerous small legs appearing like a fringe along each side of the body; crawling everywhere over the damp surface of the ground by night, and withdrawing into the crevices under chips, stones, and similar situations during the day-time."—(Fitch.)

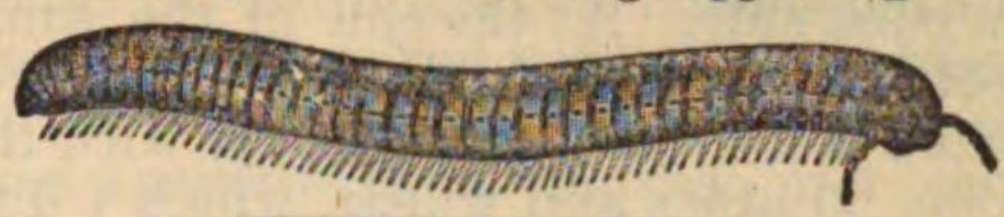

FIG. 30.—Many-lined Thousand-legs.

Although the myriapods are in general harmless, feeding either as in the case of the centipedes on other insects, or as in the millepedes on decaying vegetables or animal matter, one species of millepede (*Iulus multistriatus*) injures the roots of the strawberry in Illinois, and either this or another species, it is not known which, eats the bulbs of the carnation pink, according to a writer in the American Agriculturist. As it has been generally thought that the millipedes are harmless, feeding on dead and decaying animal and vegetable matter, I insert the statement of this writer, who lives at Montreal, Canada: "I planted out last spring a good-sized bed of carnations; two-thirds of them were cut down in about a fortnight, and I could trace it to nothing else than these worms, with which I found the bed to be infested. I removed the balance to another part of the garden, and saved them. I then examined some of the lily-bulbs in the next bed and found some of the living bulbs partly eaten, with the worms in them. I have destroyed large quantities this autumn, by slicing apples and turnips and laying them on the infested beds, the worms collecting under them in masses, which were removed and burned."

It is generally stated in systematic works on entomology that the millepedes feed on decaying vegetable or animal substances,* but there are some exceptions to this rule, which I will give.

Curtis in his "Farm Insects" tells that *Iulus londinensis* "infests the roots of wheat in Surrey," while of *Iulus latestriatus* Curtis, "thousands were infesting a garden at Nantwich." Of another species, *Iulus pilosus*, he remarks: "I have found it more than once infesting the roots of cabbages in gardens in March." A species of another genus, *Polydesmus complanatus* Linn., is, he says, "reported to be by far the most destructive species. In April, considerable numbers of the smaller ones were detected eating the roots of wheat, and in the spring and autumn they were injuring the roots of onions and pansies. They propagate rapidly when the earth is undisturbed; and specimens measuring three-quarters of an inch have been found under garden-pots at the roots of anemonies." The iuli, or snake-millepedes, Curtis adds, "seem to be both carnivorous and herbivorous, for they have been detected feeding upon small snails, as well as upon the pupa of a fly; and they are believed to live also upon larvæ, acari, earth-worms, etc.; and there is such abundant evidence of their destroying the roots of many vegetables, being found clustered together in multitudes at the roots of corn, potatoes, turnips, cabbages, etc., that there can be little doubt of their doing great mischief to many crops of the gardener, and apparently to the farmer also. In order to confirm this generally received opinion, which appeared formerly to rest upon doubtful evidence, I shall enumerate the different proofs which have come to my own knowledge. A garden at Ledbury, Herefordshire, was infested by *Iulus pulchellus*, which congregated in masses at the roots of the Brassica tribe. On pulling up some

*Curtis says that *Iulus gattatus* of Fabricius has been observed feeding on a small *Helix*.

rotten cabbage-stalks in the beginning of March I found the *Iulus pilosus* among the roots; they were then of a large size, and had, as well as I could ascertain, one hundred and fifty-six feet, being thirty-nine pairs on each side. At the end of the same month *Iulus londinensis* was detected at the roots of wheat; they were at that time an inch long, and *Iulus pulchellus* was observed with them; these I buried at the roots of some potatoes and wheat, which I dug up in August, when the former were completely decayed, but the latter were not in the least injured; and I could not detect any of the snake-millepedes. I received some roots of the scarlet-bean from Ullswater, in Westmoreland, which were eaten through and through by the *Iulus pulchellus* and *Polydesmus complanatus*, which were still sticking in the holes formed by them in the cotyledons, and the party who transmitted them stated that thousands of those species infested his garden, destroying the pease and kidney-beans also. Near Nantwich, in Cheshire, the *Iulus latestriatus* was in countless myriads in January, 1844, destroying the potted plants in the green-houses by eating the rind just at or under the surface of the soil; and cauliflowers and cabbage-plants shared the same fate in the garden. Nearly at that period of the year the *Iulus londinensis* was doing great injury to the early potato-crops near Chester. My friend, Mr. W. W. Saunders, who is too able a naturalist to be deceived, has ascertained that the iuli are very destructive in his garden at Wadsworth, where they devoured the young shoots of the heart's-ease just below the surface. I have more than once observed the snake-millepedes and *polydesmi* in September infesting the roots of onions which had been attacked by the maggots of a fly; and the *polydesmus* injures the carrot-crops by eating various labyrinths in the roots. The iuli are also found in pears, apples, etc., but I believe not in sound fruit. A few similar proofs the reader will have observed appended to the descriptions of the various species. These animals are also found in considerable numbers under the loose bark of decaying trees, in company with wood-lice, earwigs, etc.; also among the moss which clothes the base and holes in the trunk and stumps of trees, and likewise under stones in humid situations.

In his "Entomologie horticole," Boisduval tells us that *Iulus sabulosas* Linn., "sometimes enters pots, gnaws the plants at the necks of the root, and, like the sowbugs, makes it die of feebleness." *Blanniulus guttulatus* "is usually found under the straw in strawberry-beds; it introduces itself into the fruit at the time of maturity, devours the pulp, and remains coiled up in the interior like a small snake. The hole by which it penetrates is not always very large; thus it often happens that strawberries are picked which undoubtedly contain iuli. We only know it when eating them by their cracking between our teeth. This small myriapod prefers the larger species of strawberry, but the small ones which grow on *Fragasia resca* are not exempt; we have very often found them in autumn in the variety called *des quatre saisons*." The most authentative writer on the subject of the food of the millepedes is Prof. F. Plateau, of Gaud, Belgium, from whose "Researches sur les Phénomènes de la Digestion et sur la Structure de l'Appareil digestif chez les Myriapodes de Belgique," Belgium, 1876, we quote as follows: "It is commonly understood that the iuli live on vegetable matters; but the notion is general, vague, and I have found nothing exact in the works devoted to this group of animals. This leads me to state with some detail what I have myself observed. I do not believe that any iulus feeds naturally on green leaves like a caterpillar. One of our smallest species, the *Blaniulus guttulatus* (Gervais, *Iulus fragariarum* of Lamarch), eats strawberries in spring-time. Before and after the season of straw-

berries it contents itself with a food less choice; thus I have found it in abundance in the decayed bulbs of *Gladiolus communis*. The *Iulus londinensis*, so common in heaps of dead leaves and decaying vegetables, feeds on decaying vegetable tissues, and if it has to choose between green and fresh vegetables and the *débris* of rotten vegetables, it selects the latter: an individual placed in a box with green leaves of the pear, lilac, grape-vine, and grass, gnawed exclusively an old, dry, and brown pea-leaf. The *Iulus sabulosus* lives under heaps of the dried leaves of the elm, ash, oak, beach, and is nourished by them. M. Gervais has found the *Iulus lucifugus* in the tan of the green-houses of the Museum of Paris." From this statement it will be seen that as a rule these millepedes are scavengers, and more beneficial than injurious, as they live principally on decaying vegetable matter.

Returning to Dr. Fitch's account of the *Polydesmus canadensis*, he states that it eats the skin of cucumbers, and he thinks that stunted, gnarly, deformed, and bitter cucumbers are the result of the wound of these millepedes. Onions, when thickly growing together, having attained but a third or half their growth, in many cases stop growing, and the tops gradually wither and die. "On pulling up those which are thus affected, it is found that most of the thread-like rootlets underneath have been severed at the point of their junction with the bulb as smoothly and evenly as though they had been cut off with a knife, only a few of the central ones retaining their connection with the bulb." He has no doubt but that the millepedes do this. He also thinks that the disease in cabbages called anbury, or club-root, is caused by the bite of these millepedes.

THE EARTH-WORM, *Lumbricus terrestris* Linn.—Drawing young cabbage, lettuce, and beans into their holes; the common earth-worm.

It is a well-known fact that earth-worms, in the main beneficial from their habits of boring into soil of gardens and plowed lands, and thus allowing the air to get to the roots of plants, occasionally injure young seedling-plants of the cabbage, lettuce, beet, etc., by drawing them into their holes or uprooting them, working by night. They are also sometimes known to eat large holes in the tender leaves of plants. Mr. R. P. Knight thus describes the habits of the earth-worm (American Naturalist, vol. 3, p. 388): "Last spring (and this) I was led to watch the common earth-worms in my garden, and on the plot of grass saw their manner of feeding. I was within ten inches of their bodies. I saw one prepare to feed on a young clover-leaf from a clover-stock; he kept his tail secured to the hole (as a base line) in the ground, by which he retreated quicker than the eye could follow him. Finding all quiet, he came again. Within a few inches of my eye the pointed head of the worm changed, and the end was as if cut off square. I then saw it was a mouth. He approached the leaf and by a strong and rapid muscular action of the rings of the whole body drew the leaf and one inch of the tender stock into his mouth, and then by a

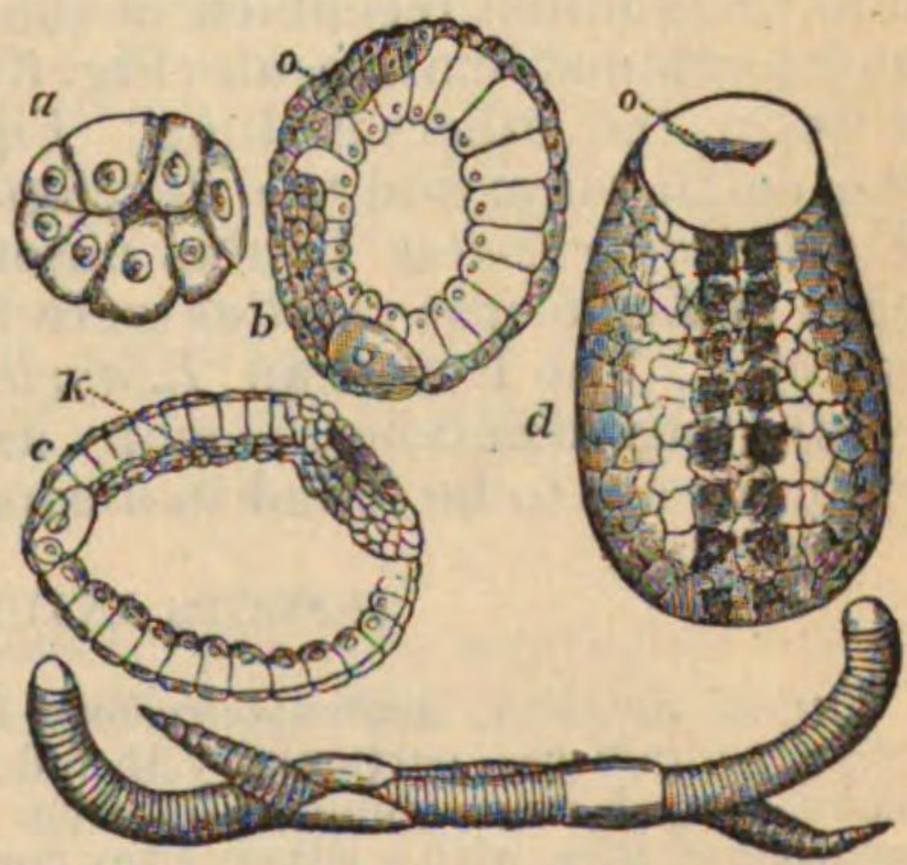

FIG. 31.—Earth-worms pairing. (After Curtis.) *a*, Embryo soon after segmentation of the yolk; *b*, embryo further advanced; (*o*, mouth); *c*, embryo still older; (*k*, primitive streak); *d*, embryo still older; (*o*, mouth, after Kowalevsky).

violent muscular action drew the whole stock of young and tender clover toward him, and when all the substance was sucked out he let the plant go and it (the stock) flew back to its former place. The leaf and stem were entire, but looked as though it had been boiled. I then laid a small piece of cold mutton down, and he appeared to feast both on the fat and lean, dragging them after him as his powers of suction could not act as well as if they had been held like the clover-leaf. I also find that when the male and female are together, they appear as one worm of double the size."

The earth-worm, like snails and slugs, is hermaphrodite. In *Lumbricus agricola* of Europe, the female sexual apparatus consists of two ovaries lying in the thirteenth segment, and two oviducts (segmental organs), which, beginning in a trumpet-shaped opening, collects several eggs into a small sac, which is ejected through an opening on each side of the ventral surface of the fourteenth segment. Moreover, we find in the ninth and tenth segments two pairs of pyriform seminal receptacles, which open into as many openings on the edges of the ninth and tenth, as well as the tenth and eleventh, segments, and during copulation are filled with sperm. The male sexual organs consist (1) of two pairs of testes, which, formed like the ovaries, lie in the tenth and eleventh segments, and (2) two seminal ducts, which begin with four trumpet-shaped openings, and terminate externally on the fifteenth segment, and (3) two seminal vesicles with several flaps and united by a cross-band and enveloped by the testes and trumpet-shaped mouths of the seminal ducts. Sexual union is reciprocal, each worm impregnating the other, and it takes place in June and July in the night-time. The worms lie with their ventral surfaces opposed, each stretched out so that the opening of the seminal receptacle of one is opposed to the girdle of the other. (See Fig. 31.)

During the act the sperm passes out to the opening of the seminal ducts, flows in a groove along the body to the girdle, and from thence into the seminal receptacle of the other worm. The eggs are very small, and contained in a capsule (Fig. 31); but, as a rule, only one egg develops a worm, the others addling. Fig. 31 illustrates the mode of pairing in the earth-worm and the development of the embryo from the egg of *Lumbricus rubellus* Grube, observed in Russia by Kowalevsky. The eggs of *Lumbricus rubellus* were found in dung, inclosed one in a single capsule. The European *L. agricola* lays numerous egg-capsules, each containing sometimes as many as fifty eggs, though only three or four embryos are to be found in a capsule (Kowalevsky).

INSECTS INJURING THE RADISH.

THE RADISH-FLY, *Anthomyia radicum* Bouché, *A. raphani* Harris.—Eating the roots of young radishes, particularly in old soils; small white maggots, which change to barrel-shaped, reddish pupa-cases, from which about the first of June emerge small, ash-colored flies, with a silvery-gray face, copper-colored eyes, and a brown spot on the front of the head, with faint brown lines on the thorax, and a longitudinal black line on the abdomen, crossed by narrower lines.

Soon after early-sown radishes come up, the roots are attacked by small white maggots, and when the plants grow in old soil the maggots are especially destructive, as I have found them in Maine over twenty years since, when the cup was badly infested. The plants were not always killed, but the roots were so worm-eaten as to be unfit for the table. Though we raised the fly in abundance, we made no notes of it at the time, and copy a description of the larvæ, pupa, and fly from Dr. Fitch's Eleventh Report. Our figures (Plate LXIII, Fig. 2) are copied

from Curtis's "Farm Insects." Dr. Fitch regards our species (*A. raphani* Harris) as identical "in every particular with the European *A. radicum*." In Europe it gnaws the roots of the turnip. The larvæ appear in the spring as soon as the radishes get partly grown. "When full-grown, they change in the ground to reddish-brown pupæ, similar to those of the onion and cabbage maggots. The insect remains in this state two or three weeks, when the fly hatches and crawls up out of the ground, with its wings crumpled up, and climbing up the side of a clod or any perpendicular surface which it finds, these members expand and assume their proper form before they become dried and firm." (Fitch.)

Description of larva.—The larva is 0.20 inch long, elongating itself to 0.25 inch when crawling. It is about three times as long as thick, appearing to be more short and broad than larvæ of the onion-fly. It is white, shining, cylindrical, and tapering to a point anteriorly, where the jaws appear under the skin as a short, black, movable line, its anterior end when protruded forward becoming split, and then seen to be two sharp hooks, which are curved downward, and when the animal is crawling these hooks are pressed downward against the surface to aid in locomotion. The body is divided by transverse lines into eleven or twelve segments, and when the head is exserted thirteen segments can be counted. At the hind end of the back a pale, tawny-yellowish dorsal stripe is faintly visible. The hind end is abruptly cut off, obliquely downward and slightly backward, forming a flat surface, having above its center two conspicuous spiracles, or elevated dots, their surface opaque and rugose, and their color sometimes tawny-yellow, sometimes black. This flattened hind end has a number of small acute teeth around its outer margin, of which the two lower ones are thicker, of a brownish color, and slightly notched or two-toothed at their tips in the large but not in the smaller young larvæ. Above these on each side are three teeth, distant from each other, the middle one nearer to the upper than to the lower one.

The fly.—In these radish-flies the two sexes differ materially. The *male* is ash-gray and very bristly; the large compound eyes occupy most of the surface of the head and are almost in contact upon their own. There are also three minute eyes at the base of the crown. The face is silvery-gray, almost white in some reflections of the light, with a long black streak on the forehead, which is pointed at its hind end. Below this streak are the black three-jointed antennæ, the basal joint being small, the second large, the third largest and oval, with a two-jointed pubescent bristle on the back, the first of the joints being very minute. The fore body is oblong, whitish on the sides, with three faint, interrupted dusky stripes upon the back. The hind body is shining gray, rather small and elliptical, tapering to the apex, with a black stripe down the back, the edges of the segments and the region of the scutel being also black. The two rings are large, transparent, iridescent, laid the one upon the other in repose, the longitudinal veins extending to the margin, with two transverse veinlets in the disk. The poisers are pale yellowish. The six legs are black and bristly, the feet five-jointed, ending in two little claws and two large pale leathery lobes.

The *female* is of a uniform ash-gray color, excepting the silvery-white face and pale sides of the fore body. The eyes are widely apart, with a broad black stripe between them, which is shaded into chestnut color in front. The hind body is larger than in the male and conical toward its apex. The wings have a tinge of yellowish at their bases. The species measures 0.22 inch in length and 0.45 inch in width across the extended wings.

Remedies.—The best preventive is undoubtedly early sowing and the rotation of crops; while infected roots should be pulled up and burned with the maggots in them, hot water should be poured on the roots, and salt and lime applied.

THE RADISH SEED-WEEVIL.—Devouring the seeds, gnawing a hole through the side of the pod; the small white grub of a pale-gray, broad, short weevil.

In the year 1857 I found in Maine upon the radish-leaves a specimen of a weevil, which I cannot distinguish by Curtis's description and figure from the European *Ceutorhynchus assimilis* Payk.

In Europe this weevil was first observed among turnip-seed, where, as a white maggot, it devours the seed in the pods; when fully fed it gnaws a hole through the side of the pod, out of which it escapes, and makes its way into the ground two or three inches below the surface, where it

forms a brown, oval cocoon of grains of dirt. Here it remains three weeks in the pupa state, and by the third week in July the beetle appears. Mr. Curtis, whose account we have reproduced, thinks that the female lays its eggs in the embryo pods.

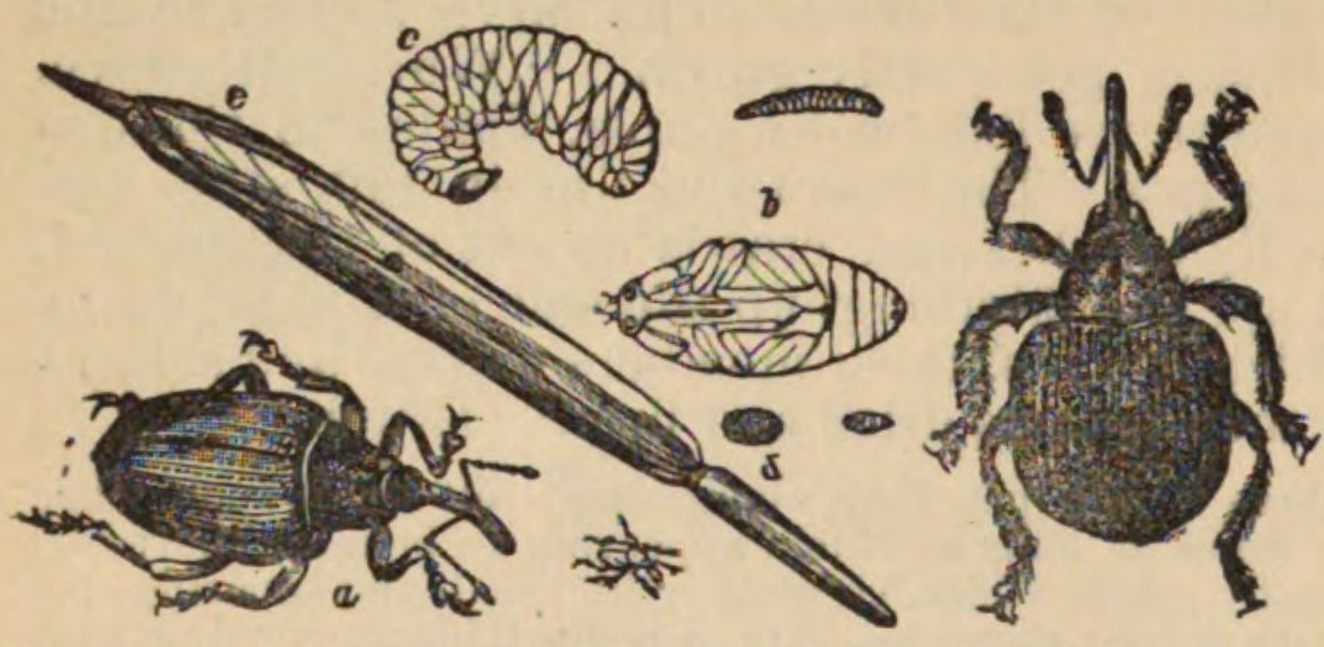

FIG. 32.—*a*, beetle; *c*, larva; *b*, pupa; *e*, pod with hole out of which the grub has come; *d*, earthen cocoon. From Curtis. The right-hand figure drawn from an American specimen.

As it has not before been noticed in this country, and may become in future years more or less of a plague, we give a brief description of the insect:

Description.—The beetle is minute and pale gray, with a remarkably long, slender, curved snout, from the middle of which arise the long elbowed, slender antennæ; the basal joint is long and slender and succeeded by seven spherical joints; the oval club pale at tip, consisting of four joints. The body is black, but so densely covered with gray, flattened hair and scales that it seems to be uniformly pale gray. These hairs become broad, flattened scales on the sides of the body. The prothorax is triangular, seen from above, swollen on the sides, and the head, exclusive of the snout, is very small. The body behind is unusually broad; the wing-covers have each nine (Curtis mentions only eight) longitudinal, fine, punctate furrows, the ridges between being much flattened. The legs are rather short, and pale gray, like the rest of the body. Curtis mentions that the hindermost thighs have a short, thick tooth beneath. I find one on the thighs of both the middle and hind legs. However, the insect may be considered identical with the European species, until proved otherwise by comparison of specimens, as it has probably been imported in radish and turnip seed.

INSECTS INFESTING LETTUCE.

THE LETTUCE EARTH-LOUSE, *Rhizobius lactucæ* Fitch.—On the roots of lettuce often in great numbers; very small, oval, white and pale-yellow lice, with dusky legs and antennæ, their bodies dusted over with a white powder.

These little lice belong to the family of true plant-lice (*Aphidæ*), but are always wingless, and with more of a white powder on the body than usual in the family, in this respect resembling the coccus or scale-insects. These little root-lice cluster about the roots of the lettuce, appearing soon after the plants are up, and becoming more numerous toward the end of the season. I have found them on the roots of the aster, and they also occur on those of the verbena. By watering the earth around the plants with tobacco-water they can be easily destroyed.

INSECTS INFESTING ASPARAGUS.

THE EUROPEAN ASPARAGUS-BEETLE, *Crioceris asparagi* Linn.—Eating irregular, rounded holes in the bark; an oblong, shining blue-black beetle a quarter of an inch long, with a red prothorax and head and three bright-yellow spots on each wing-cover; with a soft-bodied larva, thrice as long as thick, larger behind, of a dull ash-gray or obscure olive, with a black head and legs.

This beetle was first found in New York in 1858 or 1859, and in 1862 became very destructive on Long Island. Early in May, soon after the season for cutting the asparagus for the market has begun, these beetles, says Fitch, come forth from their winter-quarters and commence feeding upon it, gnawing and marring it, and scattering their eggs upon the stalks. The eggs are dark brown, small, and are attached to the stalk or leaves. They hatch in eight days, and the larva becomes fully

fed in ten or twelve days. The grub feeds upon the asparagus, gnawing through the outer bark, "preferring the tender bark on the ends of the stalks and on the branches to the more tough and stringy bark toward the base of the stem." In about thirty days from the time the egg is laid the beetle appears, and is found through the summer and autumn, hibernating in the winter in crevices in fences, etc. The beetles "feed upon the bark, eating irregular oval or oblong holes through it, lengthwise of the stalks, and varying in size from about an eighth to a quarter of an inch in length. These holes are most numerous toward the top of the stalks and on the branches, where, frequently, nearly the whole of the bark is consumed."

Description of the larva.—It attains a length of about a quarter of an inch. It is of an obscure olive or dull ash-gray color, often with a blackish stripe along the middle of the back. It is soft and of a flesh-like consistency, about three times as long as thick, thickest back of the middle, with the body much wrinkled transversely. The head is black and shining, and the neck, which is thicker than the head, has two shining black spots above. Three pairs of legs are placed anteriorly upon the breast, and are of the same shining black color with the head. As will be seen when it is crawling, the larva clings also with the tip end of its body, and all along its under side may then be seen two rows of small tubercles, slightly projecting from the surface, which serve as prolegs in addition to the tip of its body. Above these tubercles on each side is a row of elevated shining dots like warts, above which the breathing-pores appear like a row of minute black dots.

The beetle is oblong, blue-black, the prothorax bright tawny-red; the wing-covers broadly bordered with orange-yellow, while along the middle is a row of three lemon-yellow spots. The legs and under side of the body are shining blue-black, and there is frequently a dull yellowish band below the knees, and a spot of the same color on the base of the hind thighs.—(Fitch.)

Remedy.—Hand-picking and the aid of hens and chickens.

INSECTS INFESTING THE CARROT AND PARSNIP.

THE PARSNIP-BUTTERFLY, *Papilio asterias* Drury.—Feeding upon the leaves of the carrot, parsley, and parsnips; a large yellow caterpillar, smooth, cylindrical, striped and spotted with black, and changing to a large and black swallow-tailed butterfly, spotted with yellow.

Our large, common asterias butterfly is not usually common enough to be injurious, but is liable in certain seasons to be locally so. It appears in the Northern States in June, when it lays its eggs on the leaves of the carrot, parsley, and parsnip. From this brood a new set of butterflies appear in August. The larva is yellow, striped and spotted with black, and when irritated, pushes out from a slit just behind the head a V-shaped, yellow, fleshy scent-organ, used as a means of defense. The chrysalis is free, attached by the tip of the abdomen and supported by a loose silken thread, which is passed over the back. It has two ear-like projections on each side of the head and a prominence on the back of the thorax. It lives in this state from nine to fifteen days.

The butterfly is black, with a row of yellow spots across the wing and a similar row near the hinder edge, with a row of large blue patches on the hind wings between the two rows of yellow spots. The female is larger and differs from the male in wanting the inner row of yellow spots on the fore wings. The wings expand from 3½–4 inches. The obvious remedy is hand-picking. A large ichneumon fly, *Trogon exesorius*, preys upon it.

The seeds of these umbelliferous plants are often infested by minute weevils, flies, and small moths, but we know as yet but little about them.

INSECTS INFESTING THE PEA.

THE PEA-WEEVIL, *Bruchus pisi* Linn. (Fig. 33).—Infesting seed-peas, living in the pea its whole life; a rusty black weevil-like beetle, spotted with lighter shades; a little over a tenth of an inch long.

The pea-weevil belongs to a small family of beetles called *Bruchidæ*, from *Bruchus*, the name of the principal genus, of which there are 300 species known. They differ from the true weevils in the proboscis being folded on the chest, the antennæ being short and straight and inserted in a cavity next to the eyes. The beetles are short and broad, and are noted for their activity and readiness to take flight when disturbed. The pea-weevil is oval in form, about an eighth of an inch long, rusty black, with a white spot on the hinder part of the prothorax, and four or five white dots behind the middle of each elytron and a T-shaped white spot on the tip of the abdomen.

They frequent the pea during and just after the flowering season. Harris states that "after the pea-vines have flowered, and while the pods are young and tender, and the peas within them are just beginning to swell, the beetles gather upon them, and deposit their tiny eggs singly in the punctures or wounds which they make upon the surface of the pods." Other authors state that with their beak they puncture the base of the flower and lay an egg in the puncture. Riley tells us in his Third Report (p. 47) that "the eggs are deep yellow, 0.035 inch long, three times as long as wide, fusiform, pointed in front, blunt behind, but larger anteriorly than posteriorly. They are fastened to the pod by some viscid fluid which dries white and glistens like silk. As the operation of depositing is only occasionally noticed during cloudy weather, we may safely assume that it takes place for the most part by night. If pea-vines are carefully examined in this latitude (Missouri) during the month of June, the pods will often be found to have from one to fifteen or twenty such eggs upon them, and the black head of the future larva may frequently be noticed through the delicate shell. * * * * The newly-hatched larva is of a deep yellow color with a black head, and it makes a direct cut through the pod into the nearest pea, the hole soon filling up in the pod, and leaving but a mere speck, not so large as a pin-hole, in the pea." The cylindrical, thick, fleshy grub hatches, and perforates the pod, entering the pea, and there lives until it changes to a weevil; and in stored peas, hibernates within them. Their presence in the pea may be detected by a discoloration made by the larva within, corresponding to a dark spot on the pea. The grub becomes fully grown by the time the pea ripens and dries. It then bores a round hole from the hollow in the center of the pea, leaving the hull and generally the germ untouched; hence infested peas will spring up and grow. The grub changes to a pupa within the pea in the autumn, and before the spring casts its skin, becomes a weevil, and gnaws a hole through the pea; it often does not appear until after the

FIG. 33.—Pea-Weevil, natural size; *b*, much enlarged; *c*, larva, natural size and enlarged; *d*, pupa seen from above, natural size and enlarged; *g*, the beetle coming out of the pea (after Curtis); *f*, egg (after Riley).

pea is planted. Sometimes every pea in a pod contains a grub. So numerous at times is it that the cultivation of the pea has been abandoned. By diminishing the weight of the pea it causes a great loss in the crop.

The pea-weevil is a native of this country, and has been introduced into Southern and Central Europe. It was first noticed by gardeners as injurious in Pennsylvania, but is now abundant all over the Northern and Western States.

Remedies.—The seed should be kept sealed up in tin cans over one year before planting. In this way the weevils, which live but a single year, would die before being liberated. It is also customary to soak peas in boiling water for a few minutes before planting; by so doing the sprouting of the seed will be hastened and the peas get their growth in part before the weevils attack them. As the weevils appear only once during the summer, at the time when the pea usually flowers, if a second crop is planted, they will be free from the attacks of weevils.

The crow blackbird is known to destroy great numbers of weevils in spring, and the Baltimore oriole splits open the green pods in search for grubs.

INSECTS INFESTING THE BEAN.

THE BEAN-WEEVIL, *Bruchus fabæ* Riley (Fig. 34).—Injuring beans in the same manner as peas, except that the beans are tenanted by several weevils; a similar but smaller weevil.

This very destructive weevil seems, according to Mr. Riley, to be indigenous, and has become injurious in the vicinity of New York, in Illinois, and in Missouri, bidding fair to become a most formidable pest of our bean-crop. Mr. Angus has been the first to detect its ravages, having found it to be already very destructive at West Farms, N. Y. Several years since he sent me specimens, and in 1870 wrote me more particularly about its ravages, as follows: "I also send you a sample of beans, which I think will startle you, if you have not seen such before. I discovered this beetle in the kidney or bush beans a few years ago, and they have been greatly on the increase every year since. I might say much on the gloomy prospect before us in the cultivation of this important garden and farm product, if the work of this insect is not cut short by some means or other. The pea bruchus is bad enough, but this is worse."

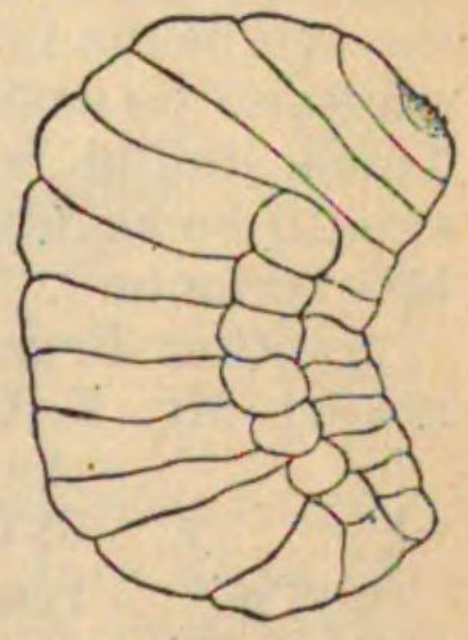

FIG. 34.—Grub of Bean-Weevil.

Description.—It closely resembles the pea-weevil (*Bruchus pisi*). It is rather smaller than the pea-weevil, measuring 0.15 of an inch in length, while the latter is 0.20 of an inch in length. Compared with that insect, it is lighter and more uniform in color, being of a tawny-gray, without the white spots so conspicuous in *B. pisi*. The uniform tawny-gray elytra are spotted with a few oblong dark spots, situated between the striæ; the antennæ also differ in having the four basal joints more reddish than in *B. pisi*, while the terminal joint is red, being blackish-brown in *B. pisi*. The fore legs are much redder, and the two hind pairs are reddish where they are dark brown in *B. pisi*. The spine on the hind femora is smaller but longer, and the antennæ are flatter, the joints being farther separated, and the whole body narrower than in *B. pisi*.

The larva (Fig. 33) is short, thick, fleshy, footless, and about $\frac{1}{7}$ inch long. The pupa is white, and measures 0.17 of an inch in length. The head is laid upon the breast, the red tip of the mandibles reaching to the base of the tarsi of the first pair of feet. The two front pair of legs are folded on the breast at right angles to the body, the tarsi of the second pair reaching a little beyond the anterior third of the body, while the hind pair are concealed beneath the wings. The elytra are laid along the side of the body, directed obliquely downward, and are marked with deep longitudinal ribs; the under or hind pair of wings, which are much narrower than the elytra, project

beyond the elytra, nearly meeting on the median line of the body. The eyes are dark and conspicuous, being red, horseshoe-like spots. The antennæ are laid upward and backward on the base of the elytra and behind the legs. The tip of the abdomen is smooth and unarmed. Length, 0.17 of an inch.

The chrysalis lies in a cavity in the bean just large enough to receive its body, there being as many as eight or twelve in a single bean. (Fig. —.) This cavity is indicated by a round, sometimes oval, semi-transparent spot 0.08 of an inch in diameter, the insect escaping through a thin orbicular, almost transparent, lid, previously gnawn by the larva, which falls off when the beetle emerges. The chrysalis is surrounded by a thin cocoon-like case, consisting of the castings of the larva (which are long, cylindrical, when highly magnified), closely packed together.

Though most of the pupæ had, November 25, changed to beetles, which had deserted the beans, many had not changed, and two or three out of the whole lot were in the semi-pupa state, the head and posterior part of the body being unchanged. By this we could determine that the larva closely resembled the larva of the true weevils in form. It is a short, thick, fleshy, cylindrical, footless white grub. The tip of its abdomen is rather blunt; its head is rather small, white, with a pale yellowish clypeus, while the mandibles are flat, short, and broad and red in color. The rudimentary antennæ form a flattened round area on each side of the clypeus. The segments of the body are not convex, being rather flattened, but the sutures are slightly impressed. The body is a little flattened beneath and very convex above, while the lateral or pleural region of the body is well marked. Length, 0.16; thickness, 0.07 of an inch.

Remedies.—The best remedy against its attacks is to carefully examine the beans in the autumn and before sowing time, when their presence can be easily detected by the transparent spots made by the larva. These should be burned, and such beans as are apparently uninjured should be soaked for a minute in boiling-hot water, so that no beetles be overlooked.

Another *Bruchus* which is not uncommon in Colorado has been sent me by Mr. F. G. Sanborn, and is *Bruchus prosopis* Le Conte (Fig. 35). As it is liable to attack the pea or bean in Colorado and the Western Territories, I add a description and figure of it. It resembles *Bruchus fabæ*, the body being of nearly the same proportions. It is larger than that species, but the markings are very similar. It may be distinguished, however, by the entire under side of the body being uniformly whitish. Length, 0.20 inch. Another species, like the other kindly identified for me by Dr. E. H. Horn, is *Bruchus amicus* Horn. It was inclosed in the same bottle with *B. prosopis*. It may at once be distinguished by its uniformly slate-gray color above and beneath, not being spotted as usual in the genus. It is slightly smaller than *prosopis*.

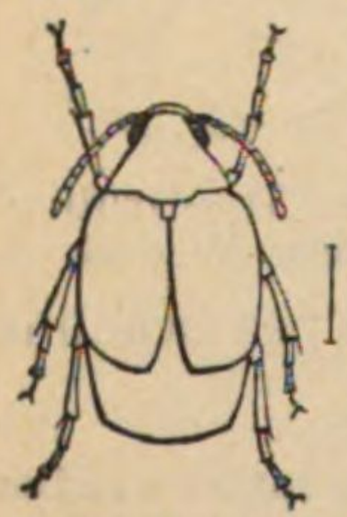

FIG. 35.—*Bruchus prosopis* Le C.

THE BEAN LEAF-HOPPER, *Empoa fabæ* (Harris).—Puncturing the leaves, causing them to wither and die, and the pods to become rough and scarred; a small pale-green leaf-hopper.

As I have had no personal experience with this insect, I copy Harris's account and description of it: "I have found that the Windsor bean, a variety of the *Vicia faba* of Linnæus, is subject to the attacks of a species of leaf-hopper, particularly during dry seasons, and when cultivated in light soils. In the early part of summer the insects are so small and so light-colored that they easily escape observation, and it is not till the beginning of July, when the beans are usually large enough

to be gathered for the table, that the ravages of the insects leads to their discovery. A large proportion of the pods will then be found to be rough, and covered with little dark-colored dots or scars, and many of them seem to be unusually spongy and not well filled. On opening these spongy pods we find that the beans have not grown to their proper size, and if they are left on the plant they cease to enlarge. At the same time the leaves, pods, and stalks are more or less infested with little leaf-hoppers, not fully grown, and unprovided with wings. Usually between the end of July and the middle of August the insects come to their growth and acquire their wings; but the mischief at this time is finished, and the plants have suffered so much that all prospect of a second crop of beans from new shoots, produced after the old stems are cut down, is frustrated.

These leaf-hoppers have the same agility in their motions, and apparently the same habits, as the vine-hoppers; but in the perfect state they are longer, more slender, and much more delicate. They are of a pale-green color; the wing-covers and wings are transparent and colorless; and the last joint of the hind feet is bluish. The head, as seen from above, is crescent-shaped, and the two eyelets are situated on its front edge. The male has two long recurved feathery threads at the extremity of the body. The length of this species is rather more than one-tenth, but less than three-twentieths of an inch wide. It may be called *Tettigonia fabæ*. Probably it passes the winter in the same way as the vine-hopper.

INSECTS INJURING THE SQUASH AND PUMPKIN.

THE SQUASH-BORER, *Ægeria* (*Melittia*) *cucurbitæ* Harris (Fig. 36).—Often suddenly killing the vine; a borer in the stalk, short and thick, with a dark head and a dark horny patch just behind it; changing to a beautiful narrow-winged, orange-colored moth spotted with black.

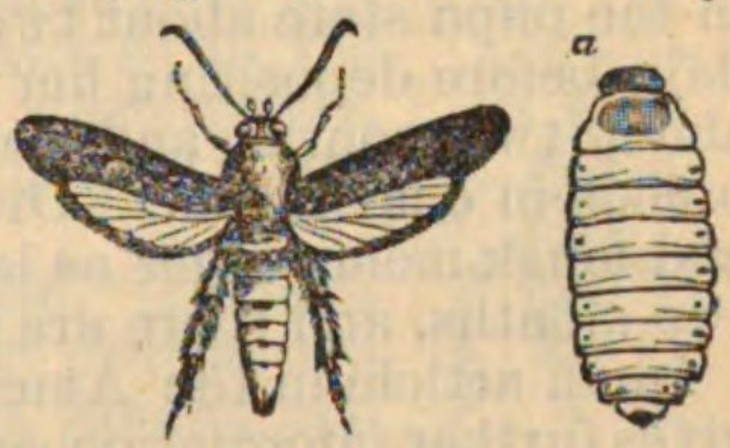

FIG. 36.--Squash-Borer; *a*, grub.

During the last of summer when the vines are nearly fully grown and the squashes have nearly attained their full size, they suddenly die as if cut off at the roots. This is the work of the caterpillar of the beautiful moth here figured. This *Ægerian* appears in New England from July 10 to August 15, when it deposits its eggs on the stalk of the vine close to the roots. The larva on hatching bores into the stalk, and when nearly grown occupies the center near the ground, devouring the interior, and thus killing the plant. Here it lives until the last of September or early in October, when it either deserts the vine and spins a rude earthen cocoon near the roots, or, as is often the case, remains in the hollow it has made in the stalk, and then changes to a chrysalis. From this fact the means of prevention against its attacks are comparatively easy, for if the vines are collected and burned in the autumn, in many cases the worms or chrysalides will be destroyed with them.

Description.—The larva is a short, thick, fleshy, white caterpillar, with short legs, and a dusky head, with a horny dark scale on the segment next behind it. The moth is exceedingly beautiful, being a member of the family of *Ægerians*, in which the wings are very narrow. The body, for one of this family, is unusually thick. It is dark green with a bluish tint. The antennæ are steel-blue. In the male the antennæ are pectinated, and the abdomen dark above. In the female the abdomen is orange-red above and beneath, except on the basal segment; on the upper side are five large dark spots. The legs in both sexes are thick, with dense stiff hairs, black and orange, forming brushes, some white hairs, and four stiff spines; a large white spot at the base of the hind legs and on the breast. Head in front white; palpi, orange. It expands nearly an inch and a half.

THE STRIPED SQUASH-BEETLE, *Diabrotica vittata* Fabricius (Fig. 37).—Appearing on the squash pumpkin, cucumber, and melon vines as soon as the leaves are up, eating holes in the leaves and killing the young plant; a small yellow-striped beetle, whose larva is a long, slender grub, which bores in the roots in June and July.

This universal pest is so familiar in the Northern States as to scarcely need description. The beetle hibernates under leaves or in the crevices in the bark of trees or in fences, appearing among the earliest insects of spring, at the time that the shad-bush (*Amelanchier canadensis*) is in blossom, on the pollen of whose flowers it feeds, afterward deserting wild flowers for the garden. As soon as the seed-leaves of the squash, pumpkin, melon, or cucumber are formed, and even before they appear above the surface of the soil, they devour them, and until the plant is about six inches high it is liable to be devoured by them. I take the following account in part from my "Guide to the Study of Insects." Dr. H. Shimer has given an account of the habits of this insect in its different stages. He states that the grub, in June and July, "eats the bark and often perforates and hollows out the lower part of the stem which is beneath the ground, and the upper portion of the root, and occasionally, when the supply below fails, we find them in the vine just above the ground." It hibernates in the pupa state. "The larva arrives at maturity in about a month after the egg is laid; it remains in the pupa state about two weeks, and the beetle probably lives several days before depositing her eggs, so that one generation is in existence about two months, and we can only have two, never more than three, broods in one season." Dr. Shimer has found them boring in the squash and musk-melon vines as late as October 1. A generation appears in two months, and there are two or three broods in a season.

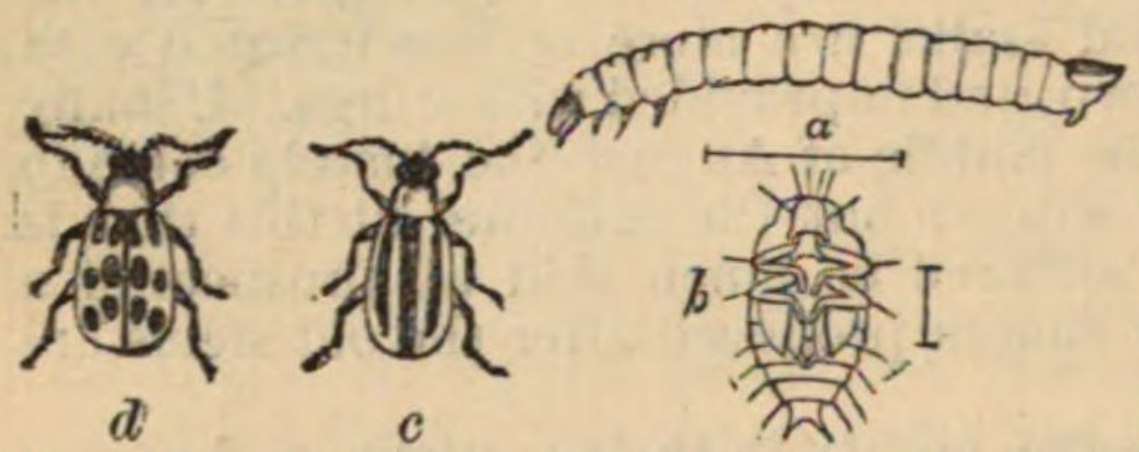

FIG. 37.—Striped Squash-Beetle; *a*, larva; *b*, pupa *c*, adult; *d*, 12-spotted Deabrotica.

In an article in the American Naturalist (vol. v, p. 217), Dr. Shimer gives further information concerning the habits of this beetle. The eggs, he says, are deposited on the root at the surface of the ground, or on the root just below the upper loose particles of earth, for although the perfect beetle does not burrow into the compact ground, yet it often is found down along the stem or root, just below the surface, under the loose, dry clots or finer particles of earth which are not pressed closely or beaten down by rains and hardened in drying.

Description of the larva.—It is a long, slender, white, cylindrical grub, with a small, brownish head. The prothorax is coreous. The thoracic legs are very slender, pale brown; the end of the body is suddenly truncated, with a small prop-leg beneath. Above is an articular brown space, growing black posteriorly and ending in a pair of upcurved, vertical, slender, black spines. It is 0.40 of an inch long. In its boring habits, and its remarkably long, cylindrical, soft, white body this larva widely differs from that of *Galleruca*, to which the beetle is closely allied. The *pupa* is 0.17 of an inch long, white, with the tip of the abdomen ending in two long acute spines arising from a common base.

A Tachina parasite (*Melanoshora diabroticæ* Shimer) preys upon this beetle in the adult state, materially reducing its numbers. A single maggot fills almost the entire cavity of the abdomen of its host, the beetle. When about to transform into the pupa, the maggot leaves the body of the fly, and its pupa-case is found in the surface of the ground, the fly appearing late in July.

Description of Melanosphora diabroticæ Shimer.—Pitch black. Eyes and proboscis light brown. Halters pale brownish. A crescentic line on each side of the face bordering the eye, almost meeting in the medial line, silvery-gray. Anterior portion and sides of the prothorax in some lights give the same lustrous gray reflections as the face; in others, blackish. Body moderately clothed with stiff black spines. Wings hyaline, iridescent, with a smoky yellowish shade toward the base. Expanse of wings, 0.24 of an inch; width of wing, 0.06 of an inch; length of body, 0.13–0.15 of an inch; described from five dry specimens.—(Shimer.)

Dr. Shimer has also found a small red mite attached to the posterior end of the body of the beetle, which is very annoying to its host.

FIG. 38.—Tachina parasite of the Squash-Beetle.

Remedies.—Covering the vines with cotton or a high frame covered with muslin or millinet is the only sure preventive, while powdered charcoal, hellebore, or lime may be sprinkled on the leaves. Mr. Gregory, says the American Agriculturist, "relies upon plaster or oyster-shell lime, which may be shaken from a small sieve while the leaves are wet with dew or rain; to be applied as soon as the plants are up. He objects to the use of air-slacked stone-lime as it is apt to be too caustic and injures the plant."

THE SQUASH-BUG, *Coreus tristis* De Geer (Fig. 39).—Sucking the sap of the stems; large black bugs, often surrounding in large numbers the stems of squash-vines in August.

While the squash-beetle is a coleopterous insect, the large black bug which is so abundant and destructive to the squash is a hemipterous insect, not having free-biting jaws as in the beetles, but a long, slender, sharp beak, lying, when at rest, on the breast, which it thrusts into the stem or leaf-stalks of its food-plant.

FIG. 39.—Squash-Bug, nat. size.

I extract the following account of it from the "Guide to the Study of Insects." The squash-bug is very destructive to squash-vines, collecting in great numbers around the stem near the ground and sucking the sap with its stout beak. It is a large, blackish-brown insect, six-tenths of an inch long, and dirty yellowish beneath. It hibernates in the adult condition, leaving the plants in October. About the last of June the sexes meet, and the females "lay their eggs in little patches, fastening them with a gummy substance to the under side of the leaves. The eggs are round and flattened on two sides and are soon hatched. The young bugs are proportionally shorter and more rounded than the perfect insects, are of a pale ash color, and have quite large antennæ, the joints of which are somewhat flattened. As they grow older and increase in size, after molting their skins a few times, they become more oval in form, and the under side of their bodies gradually acquires a dull ocher-yellow color." (Harris's Treatise). The young attack the leaves, causing them to wither. Successive broods are said to appear during the summer. The odor of this bug is very offensive. Professor Verriel has found, with the assistance of Prof. S. W. Johnson, of Yale College, that the odor of this and other hemipterous insects bears the most resemblance to that of the formate of amylic ether. It is probable that this substance is its most essential and active ingredient.

Remedies.—This insect is so conspicuous that it can readily be controlled by hand-picking, especially when fully grown.

THE SQUASH LADY-BIRD, *Epilachna borealis* Thunberg (Fig. 40).—Feeding on the leaves of the squash and pumpkin; a yellowish grub, with long branched spines.

FIG. 40.—Squash Lady-Bird.

While all the other species of the family of "lady-bird" (*Coccinellidæ*) are carnivorous, preying on other living insects, as plant-lice, etc., the present species is injurious to cucurbitaceous plants. The beetle is yellowish, with seven large black spots on each wing-cover. "The larva is yellow, with long, brown, branched spines, arranged in rows of six on each segment, except the first thoracic segment, which has only four. The pupa instead of spines has short bristles, especially on the thorax."—(Ostensacker.) Besides this beetle, the common black flea-beetle, *Haltica* (*Epithrix*) *cucumen's* Harris, punctures the seed-leaves, causing at times a great deal of mischief.

THE PICKLE-WORM, *Phacellura nitidalis* Cramer (Fig. 41.)—Boring cylindrical holes in cucumbers, causing the fruit of the cucumber, melon, or squash to decay; a pale, greenish yellow caterpillar, with a pale reddish head.

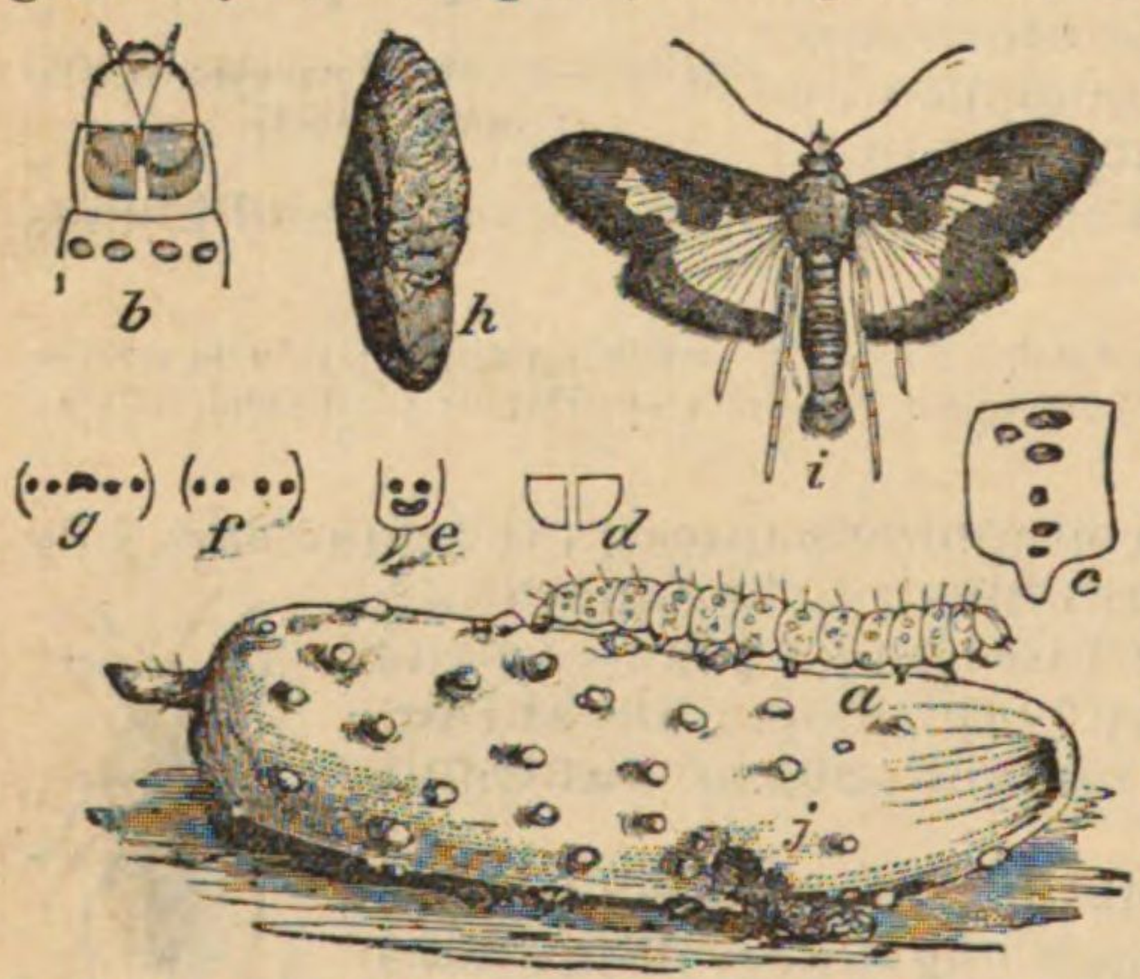

FIG. 41.—*a*, pickle-worm; *b*, head and prothoracic segment, enlarged; *c*, *d*, *e*, *f*, *g*, markings; *h*, cocoon; *i*, male moth.—(After Riley.)

According to Riley, the pickle-worm begins to appear in the latitude of Saint Louis, Mo., about the middle of July, and continues its destructive work until the end of September. "They bore cylindrical holes into the fruit and feed on its fleshy parts. They are grass-feeders, and produce a large amount of soft excrement. I have found as many as four in a medium-sized cucumber, and a single worm will often cause the fruit to rot. They develop very rapidly, and come to their growth in from three to four weeks. When about to transform they forsake the fruit in which they had burrowed, and drawing together portions of some leaf that lies on or near the ground, spin a slight cocoon of white silk. Within this cocoon they soon become slender, brown chrysalides, with the head parts prolonged, and with a very long ventral sheath which incloses the legs. If it is not too late in the season the moths issue in from eight to ten days afterward. The late individuals, however, pass the winter within their cocoons; though from the fact that some moths come out as late as November, I infer that they may also winter over in the moth state." (Riley.) The moth is yellowish-brown, with golden, yellow spots on the fore wings, and the hind wings yellow, with a broad, dark border.

Remedies.—The cucumbers, melons, or squashes can be examined and the infested ones destroyed with the worm within.

INJURING THE HOP.

THE APHIS OF THE HOP.—Clustering often in vast numbers on the branches and leaves of the hop-vine; small, greenish, wingless or winged plant-lice.

The most destructive insect of the hop at times in New England is an aphis, which it is very difficult to exterminate. The best remedy is,

when possible, to turn a powerful stream of water upon the leaves, or to shower them with soap-suds. So abundant is it in certain years in New Egland that the hop-crop has almost been cut off. The following figure of the apple aphis is introduced to illustrate the usual form of the plant-louse.

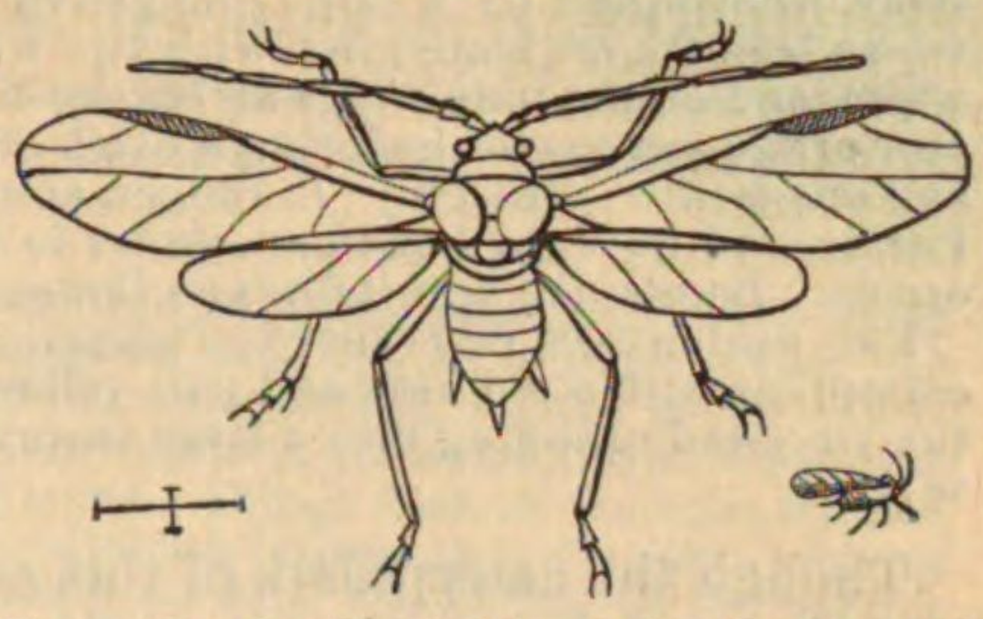

FIG. 42.—Apple Aphis, natural size and enlarged.

THE HOP CATERPILLAR, *Hypena humuli* (Harris).—Devouring the leaves in June, and again in July or August; active, slender, glass-green caterpillars, with but four false legs and nearly half an inch long.

The following account of this destructive caterpillar is taken from my "Guide to the Study of Insects." Late in May or in June, as soon as the leaves expand, they are often devoured by the caterpillar of a grunt-moth, which, on being disturbed is very active, wriggling off the leaf to the ground. It is double-brooded, the first lot of caterpillars appearing late in May and early in June, the moths flying about late in June and early in July. A second brood of caterpillars appear in July and August, in Massachusetts, the moth flying in September. When the caterpillar is fully grown it forms a loose silken cocoon within a folded leaf or any crevice, the moth appearing three weeks after. I have raised a species of parasitic fly (*Tachina*) from the chrysalides, which probably somewhat reduce the number of the moths.

FIG. 43.—Hop-vine caterpillar, pupa, and moth, natural size.

Remedies.—Hand-picking and shaking the vines vigorously twice a day would, if systematically pursued, be sufficient; while, in addition, showering the leaves with whale-oil soap, or a similar wash, would be efficacious.

Description of the caterpiller.—Body long and slender, with the segments rather convex, and with long, sparse hairs. It is uniformly of a glassy, pea-green color. The head is rather large, and deeply divided into two lobes by the median suture; it is a little more yellowish-green than the body, which tapers gradually toward the tail, while the last pair of legs are long and slender. As there are but two pairs of abdominal legs, the caterpillar walks with a looping gait like the span or measuring worms. The body is striped with a narrow whitish line, edged broadly below with dusky, and with two white lines on the sides of the body, though specimens vary in the number of lines, some having no lateral whitish stripes. It is nearly half an inch (0.45) in length. When half-grown the caterpillar is of a pale, livid, flesh color, not greenish, with a broad, dark, dorsal line, bounded on each side by a whitish line.

Description of the moth.—It has remarkably long feelers (palpi), and when the wings are folded is triangular in outlike like the Greek letter Δ. It is marbled with gray beyond the middle of the fore wings, with a distinct oblique gray stripe at the apex; and the fore wings are crossed by two wavy blackish lines formed of elevated black tufts, while there are two similar black tufts in the middle of the wings; the hind wings are paler than the rest of the moth. It expands one inch and a quarter.

THE HOP-VINE HAIR-STREAK BUTTERFLY, *Uranotes melinus* (Hübn.); *Thecla humuli* Harris.—Frequently feeding on the heads of the hop; a small, short, thick, green and downy caterpillar with very short legs, transforming into a small, delicate, brown butterfly with four linear tails, two on each hind wing.

As I have never seen this caterpillar, my account is taken from that of Harris. All he says of the larva is given in the preceding paragraph.

Description of the butterfly.—The wings on the upper side are dusky brown, with a tint of blue-gray; and, in the males, there is an oval darker spot near the front edge;

the hind wings have two short, thread-like tails, the inner one the longest, and tipped with white; along the hind margin of these same wings is a row of little pale-blue spots, interrupted by a large orange-red crescent inclosing a small black spot; the wings beneath are slate-gray, with two wavy streaks of brown edged on one side with white, and on the hind wings an orange-colored spot near the hind angle, and a larger spot of the same color inclosing a black dot just before the tails. It expands one inch and one-tenth. (Harris.) It ranges, according to Scudder, from the Atlantic to the Pacific, and from the Canadian border to the Gulf of Mexico and southward to Venezuela. Besides the hop, it feeds on *Cratægus apiifolia*, *Hypericum auream*, and *Phaseolus*.

THE SEMICOLON BUTTERFLY, *Pylygonia* (*Grapta*) *interrogationis* (Fabr.).—A brown caterpillar with a red head and pale-yellow or brownish spines, sometimes defoliating the vine, and changing into a large tawny-orange butterfly with jagged and angular wings.

Though the caterpillars of this common butterfly lives on the American elm and lime trees, it is also at times quite destructive to the hop-vine, sometimes abounding "to such a degree as totally to destroy the produce of the plant."—(Harris.) The caterpillars are so conspicuous early in August that they can be easily plucked off with the hand. The chrysalides, which late in August suspend themselves beneath the leaves and to the stems of the vine, can be picked off, though Harris recommends that the vine "should be cut down, stipped of the fruit that is sufficiently ripened, and then burned."

Caterpillar.—"Browish, variegated with pale yellow, or pale yellow variegated with brown, with a yellowish line on each side of the body; the head is rust-red, with two blackish branched-spines on the top; and the spines of the body are pale yellow or brownish, and tipped with black."—(Harris.)

Chrysalis.—"Ashen brown, with the head deeply notched, and surmounted by two conical ears, a long and thin nose-like prominence on the thorax, and eight silvery spots on the back. The chrysalis state usually lasts from eleven to fourteen days; but the later broods are more tady in their transformations, the butterfly sometimes not appearing in less than twenty-six days after the change to the chrysalis."—(Harris.)

Butterfly.—Tawny orange, wings very angular, though less dentate than in *Polygonia comma* and *progne*, but the "tails" of the hind wings are longer and more pointed. The fore wings are tawny orange, but dark brown along the outer margin, with the extreme edge washed with violet. Beneath ash-colored like old unpainted pine wood, with a large heavy silver mark of interrogation. It is much larger than *P. comma* and *progne*, expanding over two and a half (2.60) inches.

Harris states that "great numbers of the chrysalides are annually destroyed by little maggots within them, which, in due time, are transformed to tiny four-winged flies, (*Pteromalus vanessæ*,) which make their escape by eating little holes through the sides of the chrysalis."

THE COMMA BUTTERFLY, *Polygonia* (*Grapta*) *comma* (Harris).—This is a smaller butterfly than the preceding, appearing in May and laying its eggs on the leaves of the hop-vine, as well as other plants (the elm, nettle and *Baehmeria cylindrica*). The caterpillars change to chrysalides in the middle of July, their butterflies lay eggs for a new brood of caterpillars, which change to chrysalides the first of September and the butterflies hibernate.

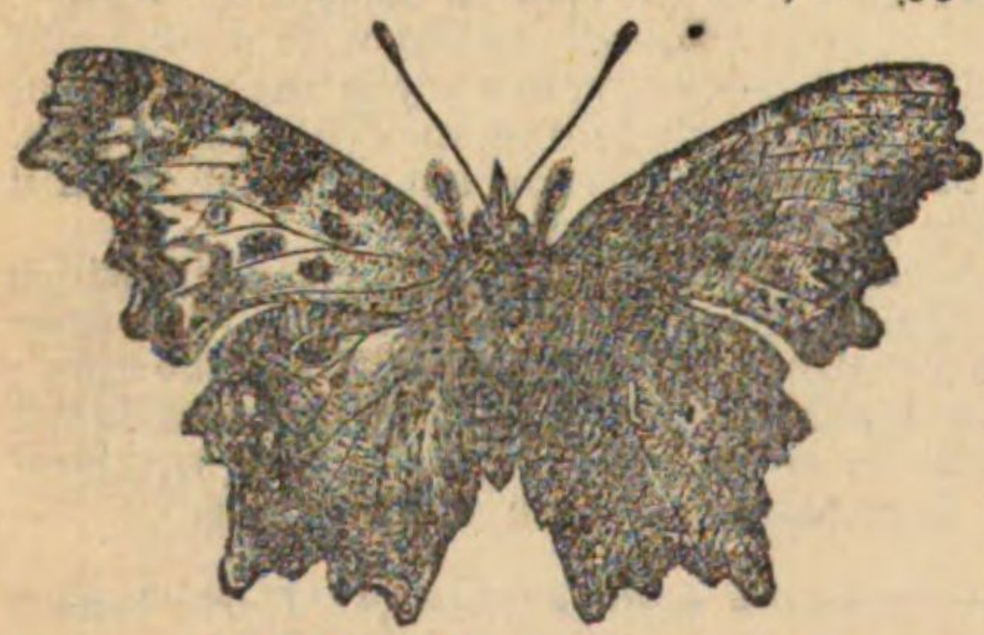

FIG. 44.—Progne Butterfly.

Description.—The caterpillar closely resembles that of *G. interrogationis*. The butterfly is much smaller than *P. interrogationis*, and the fore wings of much the same shape, but the hind wings are more toothed, with a broad, less sharp "tail." The spots and color are much the same but darker. Hind wings with an angular, slender, silvery mark, somewhat like a comma. The inner half of both wings darker wood-ash color than in *P. interrogationis*. Expanse of wings, 2¼ inches. It is very closely allied to *P. progne* (Fig. 44).

THE HOP-VINE ROOT-BORER, *Hepialus mustelinus* Packard.—This moth is closely allied to the *Hepialus humuli* of Europe, which bores in the roots of the hop. No borer has yet been detected in our vines, but it is not improbable that the above-named species will be found to attack this plant. It flies in Maine from the middle of July to the middle of August.

Description of the moth.—Female with the body and wings sable-brown. Fore wings with three broad silvery spots on the costa, margined with black; a broad silvery line along the internal margin, which is continued as a submarginal oblique straight line, dislocated near the middle of the wing, and margined with yellowish-brown with some black scales. A marginal series of triangular spots. Fringe dark at the base, spotted externally with silver. Beneath, the body is yellowish-brown, as is the front edge of the fore wings, which is banded with three dusky patches, the middle of the wing is dusky, while the legs are dark externally. It expands a little over one and a quarter (1.30) inches.

Hepialus pulcher of Grote is a species which is common in the foot-hills and mountains of Colorado during July, August, and September. It may prove destructive to the hop when cultivated in Colorado.

INJURING THE COTTON-PLANT.

THE COTTON ARMY-WORM, *Aletia argillacea* Hübner; *Anomis xylina* Say (Fig. 45).—Feeding often in vast numbers upon the leaves of the cotton-plant; a caterpillar with a looping gait, hairy, green, dotted with black along a subdorsal yellowish line, and with black dots beneath, changing to a pale reddish-brown moth.

Although this moth, and especially the caterpillar, are so abundant and destructive in the cotton-growing States, there is much that needs to be known about its habits and transformations, as good authorities differ. The following account and illustrations are taken from my "Guide to the Study of Insects," with some additions from Riley's Second Report on the Noxious Insects of Missouri, and Mr. Grote's account in Smith's Report on the Geology of Alabama for 1875, p. 199.

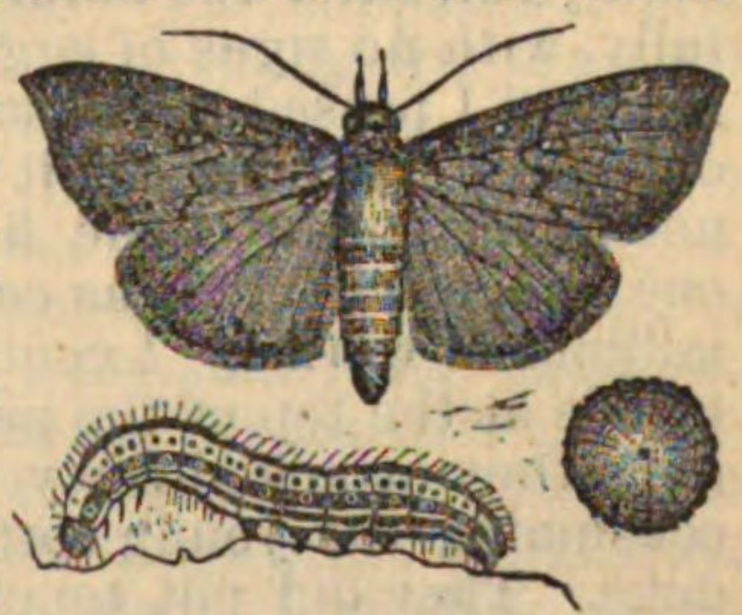

FIG. 45.—Cotton Army-Worm, Egg, and Moth.

The parent of the cotton-worm is a reddish brown moth, with a dark discal oval spot centered by two pale dots. She deposits, according to Mr. Glover, a low, much-flattened, vertically-ribbed egg upon the surface of the leaf. "Each female moth deposits from 400 to 600, and, according to the late Thomas Affbek, of Brenham, they hatch two days after being deposited, if the weather be moist and warm. The worms at first feed upon the parenchyma or soft, fleshy parts of the leaves, but afterward devour indifferently, not only any portion of the leaves, but also the blossom-bud and blossom, together with the calyx leaves at the base of the boll, thus causing the lobes which hold the cotton to fall entirely back and allow the cotton to drop at the slightest touch. While young these worms readily let themselves down by a web when disturbed, but when older they make less use of this web, and jerk themselves away to a considerable distance when suddenly touched. They cast their skins at five successive periods, and come to their growth in the incredibly short space of fifteen or twenty days."

The larva is a looper, four (the two foremost pair) out of the sixteen abdominal legs usually present in the family being wanting, so that the

caterpillar resembles the germetrid or measuring-worms in its gait. In this way it can readily be distinguished from either the northern army-worm or the boll-worm. Its body is thickest in the middle, very hairy, green, dotted with black along a subdorsal yellowish line, and with black dots beneath.

"In Central Alabama," says Grote, "I have watched the growth of the worms on the cotton-plant. The worm appears there in certain seasons, as early as the latter part of June. After feeding for a period of about fourteen days, the cotton-worms commence preparations for shedding their skin to pass into the chrysalis stage of growth. For this they spin a few loose threads of silk on the plant itself, which they rarely forsake for that purpose. Within this light web the lost larvæ skin is thrown off, and the brown chrysalis skin is exposed. In this state the worm passes from a week to ten days."

Riley states that, "according to the best authority, there are three different broods of worms during the year, the first appearing in June or July, and the last which does the most damage, appearing in August or September, or even later."

Like our northern army-worm (*Leucania unipuncta*), the cotton army-worm, the early stages of the caterpillar having been unnoticed, owing to the fact that it simulates the leaves on which it feeds and is so small, becomes suddenly visible in great numbers in a single day, committing the greatest havoc in a few hours. I extract the following account of an invasion of these cotton-worms, written by Prof. J. Darby, of Auburn, Ala., and quoted in my Guide: "Saturday, September 19, I was in the field examining the forms (buds before flowering) and the young bolls (fruit after the floral organs have fallen off). I examined all carefully, with no signs of eggs or worms. On Sunday I did not see it. On Monday I passed it as usual and observed nothing unusual. On Tuesday morning I passed it and noticed nothing unusual. On Tuesday noon every plant in the field was stripped of all its upper leaves, not one remaining as far as could be seen, and the plants were covered with millions of worms. I counted on one plant forty-six worms. They commence at the top of the plant, eating every leaf. When the leaves were gone they attacked the young bolls, eating through the perianth and consuming the young cotton. In the course of four days the work was done. They did not touch the grape, nor any other plant in the field. Many left the field and thousands were in the road and on the fences, but not one in a thousand thus escaped. To-day, September 23, there is scarcely one to be seen. Their disappearance is as mysterious as their coming. They have left no signs that I can see, either on the stalks or in the ground. They have extended over hundreds of miles, and nothing has proved a barrier to them, having been as destructive on islands in the river as elsewhere. One-third of the cotton-crop has been destroyed. Nothing of the kind has occurred in thirty years past to my knowledge."

In 1788 the cotton army-worm destroyed, at a low estimate, 200 tons of cotton in the Bahamas; in Georgia, the crop was destroyed in 1793, and it was very destructive in 1800, 1804, 1825, and 1826, and since then has been destructive in certain localities nearly each year, though not always in the same State. The average annual loss in this country is probably some years $50,000,000. So great is the annual loss that it would be well if the cotton States would each employ a salaried entomologist to investigate and report on the insects injurious to the cotton-plant. The United States Government should also employ competent entomological talent, and have the subject investigated from a broad,

scientific standpoint, as it is a matter of national interest to arrest the immense annual loss resulting from the attacks of the army-worm.

As to the original habitat of this insect there is some question. Mr. Grote believes that it is "an imported insect, and not indigenous to the Southern States." He claims that, as in our climate cotton is an introduced plant, and has become an annual, the cotton-worm has been imported with it. As he says: "The first herald of the cotton-worm I have found to be always the flight of the parent moths. These would come to light in houses, and in a few days thereafter I found the young worms on the plants. This, in Central Alabama, was in June or July, and previously I had always heard of the appearance of the worm to the southward. Before it, the cotton in my vicinity had shown no signs of worm, and, had any existed in the country, it must have showed itself during the preceding three months, while the young cotton-plants were growing. In favorable seasons the broods were successive until frost, and the death of the cotton-plant. Where food failed on one plantation the worms wandered to another, and not till then. The first brood in one locality is irregular, skipping some plantations, invading others. Again, I have noticed that, while there was yet leaf enough left, and the season yet warm, whole sections would be forsaken by the freshly-disclosed moths. There is no doubt on my mind that the cotton-worm has a yearly migration northward, from the facts in the case. The cold weather finally kills the moths, without their being able to provide for a further brood. I have noticed the moth in the fall as far north as Canada and the great lakes, and on the coast of Maine.* Always arriving there late in the season, it must perish; there is no food for its progeny; it is too late for it to retrace its steps." This supposed migration northward of the cotton army-worm is an interesting and practical subject for further investigation. As yet I am hardly inclined to suppose that this particular species should not live in all its stages where it is now found, and I think that further research will prove that it is so. It should be remembered that the caterpillars of a good many species of this family do not hatch out until toward midsummer, for example, the northern army-worm. Its larva should be looked for in the Northern States where it occurs, and, if found, the food-plant ascertained. It is possible that the chrysalides have been carried north in cotton-bales, but under the circumstances in which I have seen the moth flying on an island in Salem Harbor, I do not doubt but that the caterpillar will be found. I have taken several specimens of this moth on Coney Island in Salem Harbor. Mr. Edward Burgess informs me that it flew aboard his yacht in Boston Bay, September 9, 1873. Mr. Grote records it from Buffalo, N. Y., and Mr. Riley from Chicago.

In the accompanying map showing the area of distribution of the cotton army and boll worm, I have indicated the area in which it is permanently destructive, being the cotton-growing portion of the Southern States, taken from Walker's Statistical Atlas.

Description of the moth.—Pale brown, with a slight reddish tinge; hind wings somewhat paler. Fore wings with three indistinct irregularly scalloped reddish lines, the basal one on the inner third of the wing composed of four or five scallops; the second is situated deyond the middle of the wing, and branches out behind the middle (transversely) of the wing, and sends a branch just beyond the discal dot, forming a third line. The scallops differ in size, but the line curves out most just below the costa, and again opposite the discal spot, which is large, dark, conspicuous, obliquely oval, and centered with two unequal bluish spots. Expanse of wings, 1.55 inches. Salem, Mass., Demopolis, Ala., and Waco, Tex., September 5, October 12, and November 15.—(Belfrage.)

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* This is most probably a mistake for Massachusetts, as I am quite sure it has not been observed north of Salem, Mass.

Remedies.—Picking the caterpillars off the plants by hand, ditching, and the use of burning straw when the caterpillars migrate from one field to another, are remedies that can be applied in the cotton States, when labor is cheap, to good advantage. By these means, and the use of Paris green, the evil can be stamped out, provided co-operation is practised among adjoining plantations. The same means should be used as with the northern army-worm and potato-beetle. The most serviceable remedy has been the use of Paris green, either dry, mixed with cheap flour, or in water, in proportions sufficient to kill the caterpillars without injuring the plants. This remedy has been successfully tried in the South. I take the following modes of using this poison from Mr. Riley's Sixth Report. In Texas, by the use of Paris green mixed with lime or plaster, or even fine sand, "a neighbor has picked already 10 bales of 500 pounds each from 13 acres, while freedmen on the same farm lost their whole crop by refusing to use it." Repeated applications should be made after the appearance of successive broods of worms. By some, it is said application should not be made after the bolls are open, lest it become dangerous to picker and ginner." Mr. J. R. Maxwell, of Alabama, writes to the Southern Farmer: "I have been successful in the use of Paris green on the cotton-worm. I had 100 acres of cotton on swamp-land that would have been ruined, but on their first appearance I commenced on them. I put eight hands on mules, with two-gallon watering-pots, and had ten more hands and two wagons engaged in keeping them supplied with water and poison, and went over my cotton twice, up one side of a row and down the other, going thus twice to each row. Poison, labor, and all cost me about $300. It has saved me at the very least 20 bales of cotton. I used the poison by putting to each canful of water half a table-spoonful of poison and three table-spoonfuls of flour, stirring it well. I tried it first without flour, but every shower would wash all the poison off." Another Alabama farmer successfully used the powder-mixture on 50 acres at a cost of 68 cents an acre. Mr. D. F. Prout says that the cost of material an acre "for two applications will not exceed $1.75, viz: 40 pounds of flour, at 2½ cents per pound, and 2 pounds of Paris green, at 37½ cents." He found, in his own experience, that an expenditure of $100 on about 80 acres increased the crop at least 10 bales.

THE BOLL-WORM, *Heleothis armigera* Linn.—Eating the boll of the cotton-plant, corn in the ear, tomato-fruit, etc.; a rather large, thick-bodied, pale-green or dark-brown caterpillar, with longitudinal light and dark lines, and with a broad yellow band below the breathing-pores, and marked with black spots, from which arise fine hairs.

This moth is a cosmopolitan, being injurious in Europe, and inhabiting Japan and even Australia. It feeds on a variety of plants, not only devouring the calyx of the flower but the boll, and corn in the ear as well as the stock, unripe and ripe tomates, green pease, string-beans, and young pumpkins. It bores into the stalks of the gladiolus, and in Europe is known to devour the heads of hemp and leaves of tobacco and of lucern, as well as chick or coffee pea.—(Riley.)

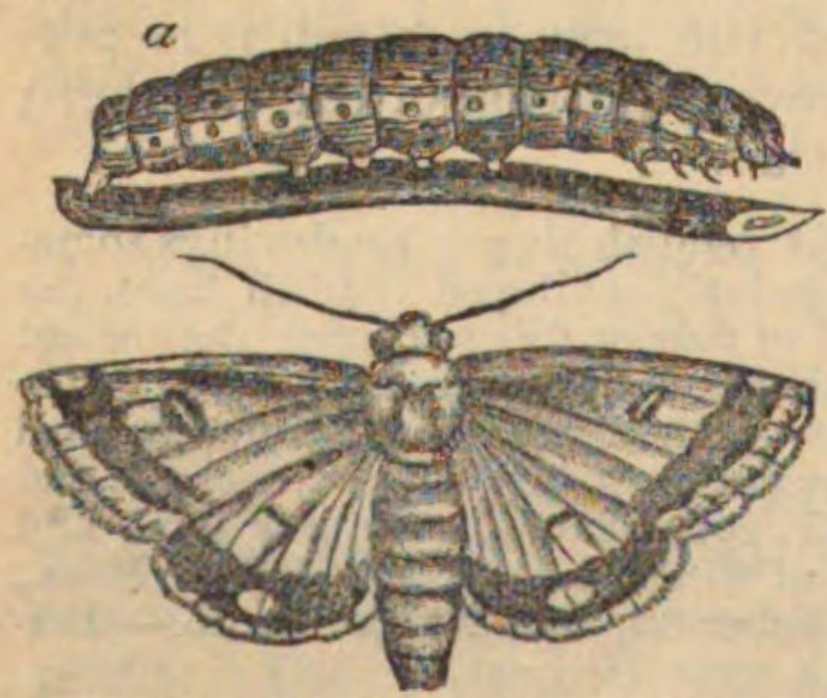


FIG. 46.—Boll-Worm and Parent Moth. (After Glover.)

"The egg from which the worm hatches is ribbed in a somewhat similar manner to that of the cotton-worm, but may readily be distinguished by being less flattened and of a pale straw color in-

stead of green. It is usually deposited singly on the outside of the involucel or outer calyx of the flower or young boll, and each female moth is capable of thus consigning to their proper places upward of five hundred eggs."—(Riley.)

"Some eggs of the boll-worm hatched in three or four days after being brought in from the field, the inclosed worms gnawing a hole through the shell of the egg, and then escaping. They soon commenced feeding upon the tender, fleshy substance of the calyx near the place where the egg had been deposited. When they had gained strength, some of the worms pierced through the calyx and others through the petals of the closed flower-bud, or even penetrated into the young and tender boll itself. The pistils and stamens of the open flower are frequently found to be disturbed and injured without any apparent cause. This has been done by the young boll-worm; when hidden in the unopened bud, it has eaten one side only of the pistils and stamens, so that when the flower is open the parts injured are distorted and maimed, and very frequently the flower falls without forming any boll whatever. In many cases, however, the young worm bores through the bottom of the flower into the immature boll before the old flower falls, thus leaving the boll and involucel, or envelope, still adhering to the foot-stalk with the worm safely lodged in the growing boll. The number of buds destroyed by this worm is very great, as they fall off when quite small, and are scarcely observed as they lie brown and withering on the ground beneath the plant. The instinct of the boll-worm, however, teaches it to forsake a bud or boll about to fall, and either to seek another healthy boll or to fasten itself to a leaf, on which it remains until at length it acquires size and strength sufficient to enable it to bore into the nearly-matured bolls, the interior of which is nearly destroyed by its attacks, as, should it not be completely devoured, rain penetrates through the hole made by the worm, and the cotton soon becomes rotten and will not ripen. * * * One thing is worthy of observation, and that is whenever a young boll or bud is seen with the involucre spread open and of a sickly yellow color, it may be safely concluded that it has been attacked by the boll-worm, and will soon perish and fall to the ground.

* * * * * * *

"The buds injured by the worm may be readily distinguished by a minute hole where it has entered, and which, when cut open, will be found partially filled with small black grains, something like coarse gunpowder, which is nothing but the digested food after having passed through the body of the worm."—(Glover, Monthly Agricultural Report, July, 1866.)

When fully grown, the worm descends into the ground, there forming an oval cocoon of earth interwoven with silk wherein it changes to a bright chestnut-brown chrysalis with four spines at the end of the body, the two middle ones being stouter than the others. In this state it remains three or four weeks when the moth escapes. Mr. Glover says that "there are at least three broods each year in Georgia, the last brood issuing as moths late in November. With us (Missouri) there are usually but two, though as already hinted there may be exceptionally three. Most of the moths issue in the fall and hibernate as such, but some of them pass the winter in the chrysalis state and do not issue till the following spring. I have known them to issue in this latitude after the first of November, when no frost had previously occurred."—(Riley.)

Description of the moth.—I regret that there is no good description of the caterpillar in existence and that I have no opportunity to study these caterpillars either in a

state of nature or preserved in alcohol. Specimens in all stages would be very welcome. The moth is pale tawny, the hind wings whitish. The fore wings are uniformly pale tawny yellowish, with a small, not very distinct, oval, dark discal dot. Half-way between this and the outer edge of the wing is a row of whitish points, shaded with black within; fringe, flesh red. Hind wings whitish, blackish on the outer two-thirds, with a white fringe. Expanse of wings, 1.40 to. 1.60 inches. I have received specimens from Mr. Belfrage, of Waco, Tex., taken May 18, June 22, July 29, and August 6.

Remedies.—This caterpillar is difficult to manage, as it is hidden most of its life. Hand-picking, if thoroughly tried, will save much loss. The moths may be trapped by spreading a mixture of vinegar and sugar over foods or in plates, and moth-traps should be liberally used. A moth closely allied to this and which in the caterpillar as well as moth state may be easily confounded with the boll-worm, is the so-called phlox worm, originally described by Messrs. Grote and Robinson under the name of *Heliothis phloxophaga.* It occurs all over the South and west as far as California and Oregon. Professor Riley, in the Prairie Farmer, states that there are "two broods a year, the first appearing in July and becoming moths by the middle of August, the second passing the winter in the chrysalis state. The eggs are deposited singly on all portions of the plant, and the caterpillar when about to become a chrysalis enters the ground and interweaves grains of sand with a few silken threads, forming a very slight elastic cocoon."

Description of the moth.—It is usually a little smaller than *H. armigera* and with a large black discal spot fully twice as large as in that species. A dark tawny band runs from the discal spot to the inner edge of the wing. In front of the discal spot are two dark, small costal spots, and a third much larger, one near the apex. Hind wings with a very large, black lunate discal spot, almost entirely wanting in *H. armigera*, while as in that species the black border incloses a white spot, usually, however, much better marked than in *H. armigera.* Expanse of wings, 1.00-1.40 inches.

INSECTS ATTACKING THE TOBACCO-PLANT.

THE TOBACCO-WORM, *Sphinx 5-maculata* Haworth.—Devouring the leaves; a large green caterpillar as thick as one's little finger, with a stiff horn on the end of its body, and changing to a chrysalis in the earth, the moth flying in June to September.

About the only serious enemies of the tobacco-plant are the two species of *Sphinx* moths, *Macrosila carolina* Linn., and *Macrosila 5-maculata*, or the Carolina and five-spotted hawk-moth. The Carolina worm is confined to the Middle and Southern States, while the caterpillar of the five-spotted hawk-moth occurs in the Northern and Western States, as well as the Southern. I have received *M. 5-maculata* from Salt Lake City, through Mr. Joseph L. Barfoot, curator of the Salt Lake museum.

So far as my personal knowledge extends, the tobacco-worm is injurious to the tobacco-crop of the Connecticut Valley in Connecticut and Western Massachusetts, and is only kept under by watchfulness, being picked off by hand. In the Middle States, for example Tennessee, the ravages of the "tobacco-worm," as stated by the Scientific Farmer, which may refer either to this insect or the Carolina sphinx, is a great hinderance to the successful cultivation of tobacco in Tennessee. "But," adds the editor, "an enemy to it has appeared in the person of an ichneumon-fly, which destroys the worms in large numbers. It is thought if this ichneumon keeps at its work, that certain lands will possess a high value for the cultivation of tobacco." The accompanying cut (Fig. 48) represents an ichneumon-parasite, a species of *Microgaster*, bred by

Mr. J. H. Emerton, from *Macrosila 5-maculata ;* the cross-lines represent the natural size, and *a*, the cocoon, natural size.

FIG. 47.—Tobacco-Worm, Chrysalis, and Moth.

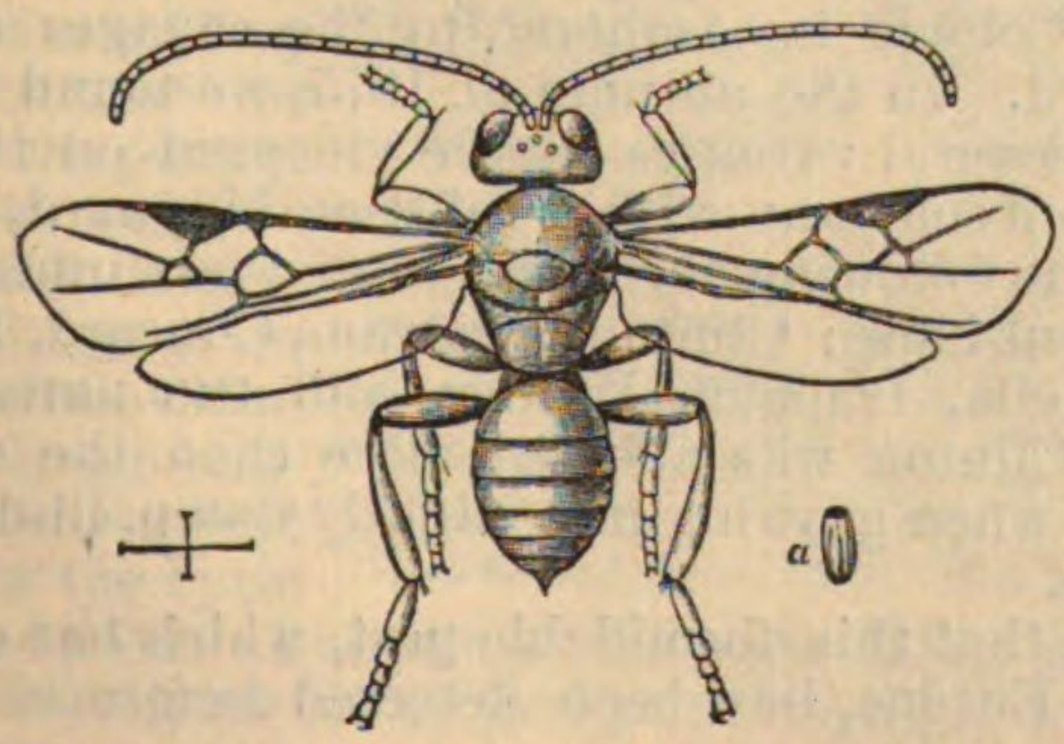


FIG. 48.—Ichneumon-parasite of the Northern Tobacco-Worm.

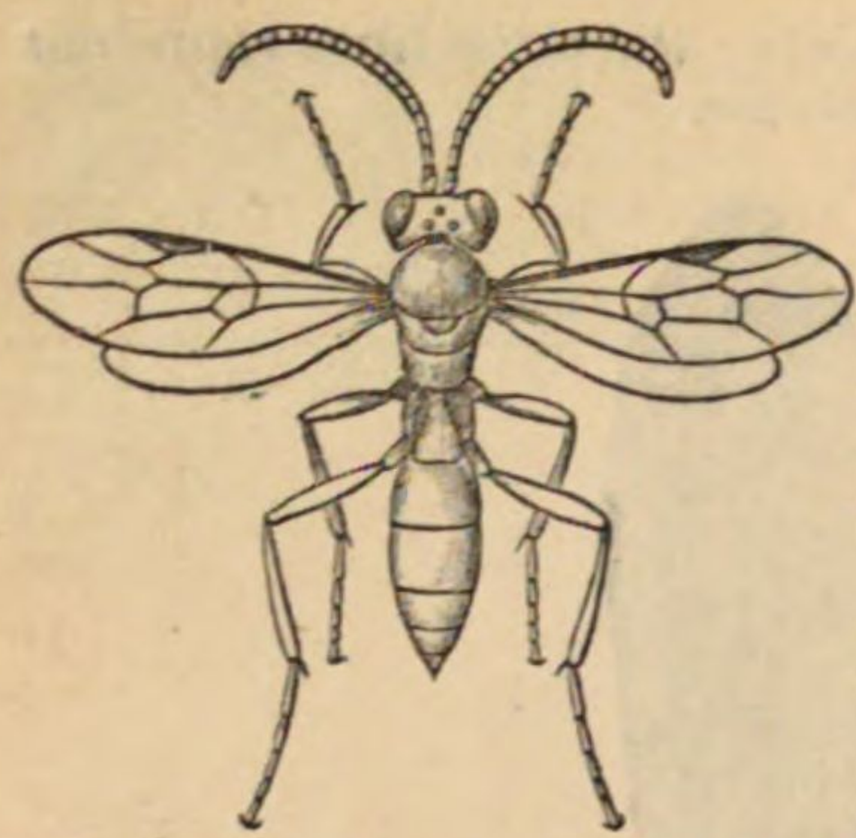


FIG. 49.—Ichneumon-parasite of Vine-Dresser.

Fig. 49 illustrates an ichneumon-parasite of the vine-dresser, *Chœnocampa pampinating*, reared at Salem, Mass., by Mr. Emerton, by whom the drawings of both were made. Professor Riley notices a species of *Microgaster* and ichneumon, an undescribed species of *Blacus*, a braconid ichneumon, which preys on the five-spotted sphinx.

The moth in the Northern States appears in June, without doubt, though I have not personally seen them, lays its eggs on the leaves, probably the under side, and the caterpillar lives about six weeks, attaining its full size from the middle of August until the first of September, going under ground in September and early October. During this month I have frequently seen the moths at twilight in Amherst, Mass., flying about the flowers of the petunia, probing their deep tubular cerollas with their long tongue. Our figure, (47,) copied from Harris, will sufficiently indicate the size and transformations of this common moth, the caterpillar of which, in the Northern States, often passes under the name of the tomato or potato worm.

The caterpillar is rather dark green, with seven oblique greenish-yellow stripes on the side of the body. The chrysalis may be known by the large, conspicuous tongue-case which projects from the body like the handle of a pitcher.

In the *Macrosila 5-maculata* there is no white spot at the base of the fore wings, and on the hind wings are two distinct angulated bands.

The Carolina moth is ash-colored, with a white spot at the base of the fore wings, while the central band of the hind wings is indistinct. The caterpillar feeds on the tobacco and the tomato. It is dark green, with lateral, oblique, white bands, edged above with bluish and short transverse black stripes. The tongue-case is shorter and less curved than in the five-spotted sphinx.

INSECTS INJURING THE GRAPE.

THE GRAPE PHYLLOXERA, *Pemphigus vitifoliæ* Fitch; *Phylloxera vastatrix* Planchon.—What the Colorado potato-beetle is to the potato, the Hessian fly to wheat, and the canker-worm is to the apple, the phylloxera is to the grape. This amounts to saying that the vine is in danger of extermination from the latter insect. My attention has been drawn for two years past, while spending a few weeks in September at the Agricultural College in Amherst, to the ravages of this pest, by Professor Maynard. In the autumn of 1875, we found it in abundance on the leaves of several varieties in the vineyard on the college farm, while this year, in company with Professor Maynard, I examined the roots and found the following varieties more or less infested by the root-variety of this plant-louse: Clinton, Agawam, Concord, Iona, Delaware, Adirondack, Israella, Isabella, Wilder, and the native grape under cultivation; the Clinton was affected more than the others, and the Concord much so when growing in a slightly damp, ill-drained and partially shady place.

I am not aware that this formidable pest, which has occasioned such consternation in Europe, has been detected before in New England,

except in Connecticut, where it has been found by Mr. Riley. I received it several years ago from Philadelphia, and it has done much damage in the Middle and Western States, while it is known to affect vines in California. As we are destined to be greatly annoyed by it, a brief description condensed from the excellent account by Mr. Riley in his sixth, seventh, and eighth report of the insect in its two forms, may be timely. The insect was first found in this country, and was described by Dr. Fitch in 1856, under the name of *Pemphigus vitifoliæ.* Its proper name is *Phylloxera vitifoliæ*, though most authors speak of it as *Phylloxera vastatrix.* It exists in two forms, one raising irregular galls on the leaves, and the other forming small swellings on the rootlets. The root-form is both wingless and winged, the latter very rare. The leaf-form is said to be always wingless.

The wingless female of the leaf-form lays, on an average, 200 eggs, and sometimes 500. There are perhaps five generations in a year. This leaf-form produces round, irregular galls, sometimes as large as a pea, but it does little damage compared with the root-form, which is much more abundant than the leaf-form (especially on native vines) in France, where its ravages have been so alarming that the French government have offered a reward of 300,000 francs for a simple available remedy.

The leaf-form descends to the roots in the autumn, and there hybernates. The larvæ of the root-form are at first smooth and like the young of the leaf-form, but afterward molt and become warty, so as to become readily distinguishable from them.

Professor Riley and certain French observers have lately proved that the gall-producers (or the leaf-form) come from the impregnated or winter egg.

The winged females begin to appear in July, but are most abundant in August and September. Like the wingless females, they reproduce by budding (parthenogenesis), the eggs not being fertilized by males, no males being in existence. Having issued from the ground while in the pupa state, they rise in the air, and spread to new vineyards, where they lay two or three, sometimes eight eggs. These eggs are of two sizes, and, in about a fortnight, from the larger eggs are hatched wingless true sexual females, and from the smaller eggs wingless males. "The abdomen of the female, after impregnation, enlarges somewhat, and she is soon delivered of a solitary egg, which differs from the ordinary eggs of the parthenogenetic mother, only in becoming somewhat darker. This impregnated egg gives birth to a young louse, which becomes a virginal, egg-bearing, wingless mother, and thus recommences the cycle of the species' evolution. But one of the most important discoveries of Balbiani is that, during the latter part of the season, many of the wing-

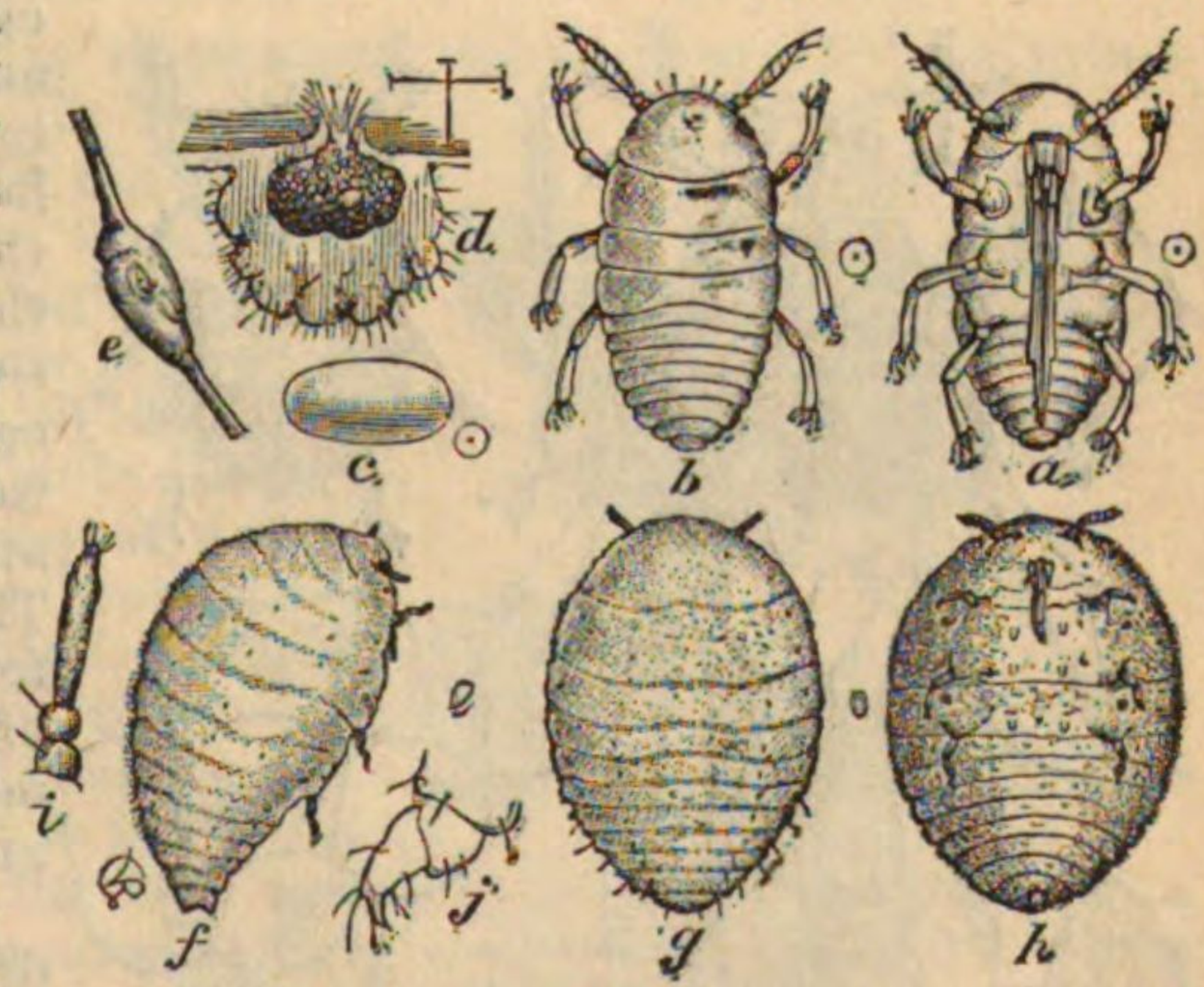


FIG. 50.—Type *gallæcola.* *a*, *b*, newly-hatched larva, ventral and dorsal view *c*, egg; *d*, section of gall; *e*, swelling of tendril; *f*, *g*, *h*, mother gall-louse, lateral, dorsal, and ventral views; *i*, her antenna; *j*, her two-jointed tarsus. The figure on the side of each enlarged drawing represents the natural size. (After Riley.)

less, hypogean mothers perform the very same function as the winged ones; *i. e.*, they lay a few eggs, which are of two sizes, and which produce males and females, organized and constructed precisely as those born of the winged females, and, like them, producing the solitary impregnated egg. Thus, the interesting fact is established that even the winged form is by no means essential to the perpetuation of the species; but that, if all such winged individuals were destroyed as fast as they issue from the ground, the species could still go on multiplying in a vineyard from year to year. We have, therefore, the spectacle of an underground insect, possessing the power of continued existence, even when confined to its subterranean retreats. It spreads in the wingless state from vine to vine, and from vineyard to vineyard, when these are adjacent, either through passages in the ground itself or over the surface; at the same time it is able, in the winged condition to migrate to much more distant points."—(Riley.)

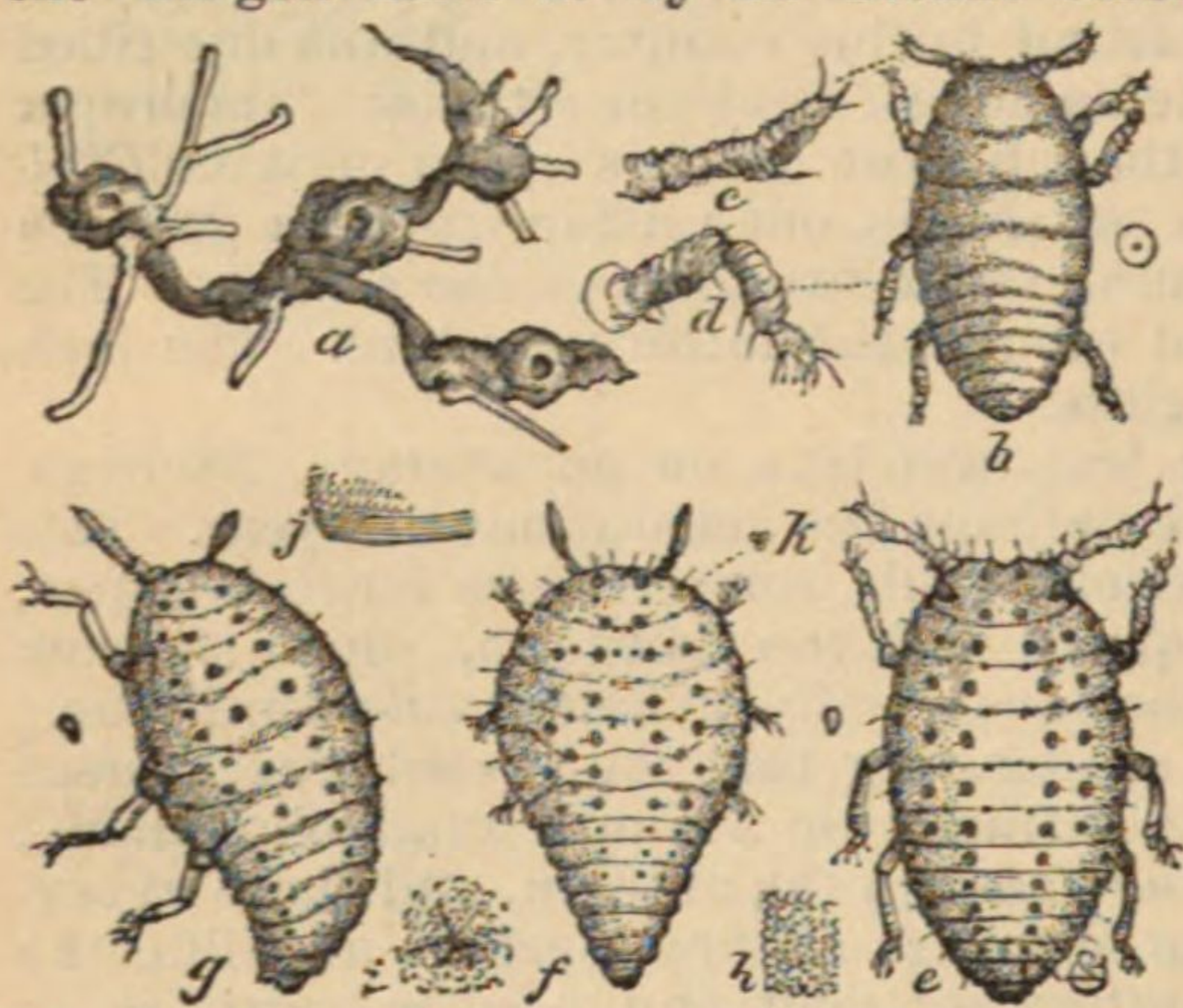


FIG. 51.—Type *radicicola*. *a*, roots of Clinton vine, showing the relation of swellings to leaf-galls, the power of resisting decomposition; *b*, larva, as it appears when hibernating; *c*, *d*, antenna and leg of the same; *e*, *f*, *g*, forms of more mature lice; *h*, granulations of skin; *i*, tubercle; *j*, transverse folds at border of joints; *k*, simple eyes. (After Riley.)

The solitary egg above referred to is the winter egg. As autumn advances, the winged individuals become more and more scarce, and only eggs, newly-hatched larvæ, and a few wingless, egg-bearing mothers are seen. The latter are said to die during the winter, and consequently the species in winter is represented by the larvæ and a few eggs. In spring the larvæ molt their winter coat, and, after attaining maturity, lay eggs. The eggs laid by the winged females are placed in the down of the leaf of the vine, but more commonly in the earth around the roots.

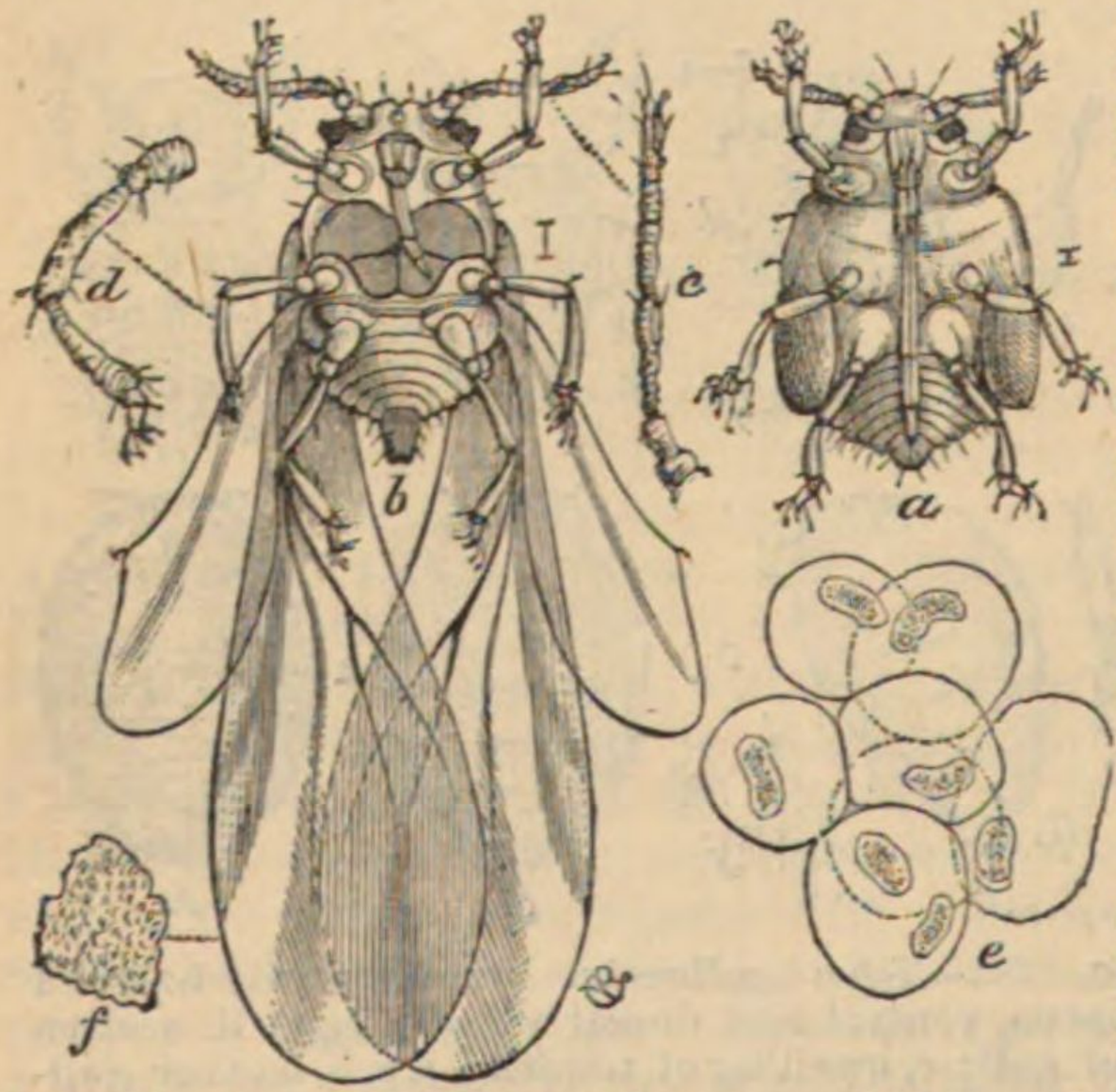


FIG. 52.—Type *radicicola*. *a*, *b*, pupa and imago of a problematic individual, or supposed male; *c*, *d*, its antenna and leg; *e*, vesicles found in the abdomen. (After Riley.)

As to remedies, one hundred and forty have already been proposed in France, but none are infallible. The best general remedy is flooding the vineyards in autumn or winter. The best specific application has been found to be the bisulphide of carbon, two ounces to be placed in a hole near the root, the earth becoming impregnated, the insects are killed. Mr. Riley has urged

the use of resisting American vines as stocks, and this is undoubtedly one of the best preventive measures which can be adopted. The writer would like to know how extensive in the Eastern States is the distribution of the phylloxera. The galls are at once recognizable, and appear in midsummer, while the root-form may be detected by little swellings on the rootlets, in which the small greenish-yellow lice may be detected after close examination.

The following recapitulation of the different forms in the insect is taken from Professor Riley's article on the *Phyollexera* in Johnson's Cyclopedia:

1. The gall-inhabiting type (*gallæcola*), forming galls on the leaves, and presenting—
   a, The ordinary egg (Fig. 50, *c*), with which the gall is crowded;
   b, The ordinary larva, (Fig. 50, *a*, *b*);
   c, The swollen parthenogenetic mother, without tubercles (Fig. 50, *g*, *h*);
2. The root-inhabiting type (*radicicola*), forming knots on the roots, and presenting—
   a a, The ordinary egg, differing in nothing from *a*, except in its slight large average size;
   b b, The ordinary larva, also differing in no respect from *b*;
   d, The parthenogenetic, wingless mother, the analogue of *c*, but covered with tubercles (Fig. 55, *g*, *f*);
   e, The more oval form, destined to become winged;
   f, The pupa, (Plate LXVIII, Fig. 1 *e*);
   g, The winged, parthenogenetic female (Plate LXVIII, Fig. 1 *g*, *h*);
   h, The sexual egg deposited by *g*, being of two sizes, and giving birth to the two males and females;
   i, The male (Plate LXVIII, Fig. 2 *e*);
   j, The true female (Plate LXVIII, Fig. 2, *a*, *b*);
   k, The solitary impregnated egg deposited by *j*;
   b b b, The larva hatched from *k*, which, so far as known, does not differ from the ordinary larva, except in its greater prolificacy;
   l, The hybernating larva, which differs only from *b* in being rougher and darker.

THE GRAPE FORESTER, *Alypia octomaculatu* Fabr. (Fig. 53).—Devouring the leaves; bright orange, blue and black banded caterpillars.

By the time the syringa is in blossom, the eight-spotted, or grape-forester moth flies about. It is easily known by its black hue, with eight large spots on the wings, two on each wing, those on the fore wings being yellowish, those on the hind wings white. The caterpillar is banded with whitish-blue, with black lines, and on the middle of each segment is a broader orange-yellow band dotted with black, with a conspicuous white spot on each side behind. It is an inch and a quarter long. By the middle of July it becomes fully fed, and pupates in slight webs on the ground or in earthen cocoons. Hand-picking is the best remedy. This insect is briefly mentioned here, from the fact that a similar caterpillar was very common at Golden, Colo., July 3, 1875, on the wild grapes by the side of the railroad, and when the cultivated varieties become reared extensively, it will probably transfer its affections from the wild to the cultivated varieties. The caterpillars of several species of similar moths which occur in California, the genus *Alypia* being more numerously represented on the Pacific coast than elsewhere, may ultimately be found injurious to the cultivated grape.

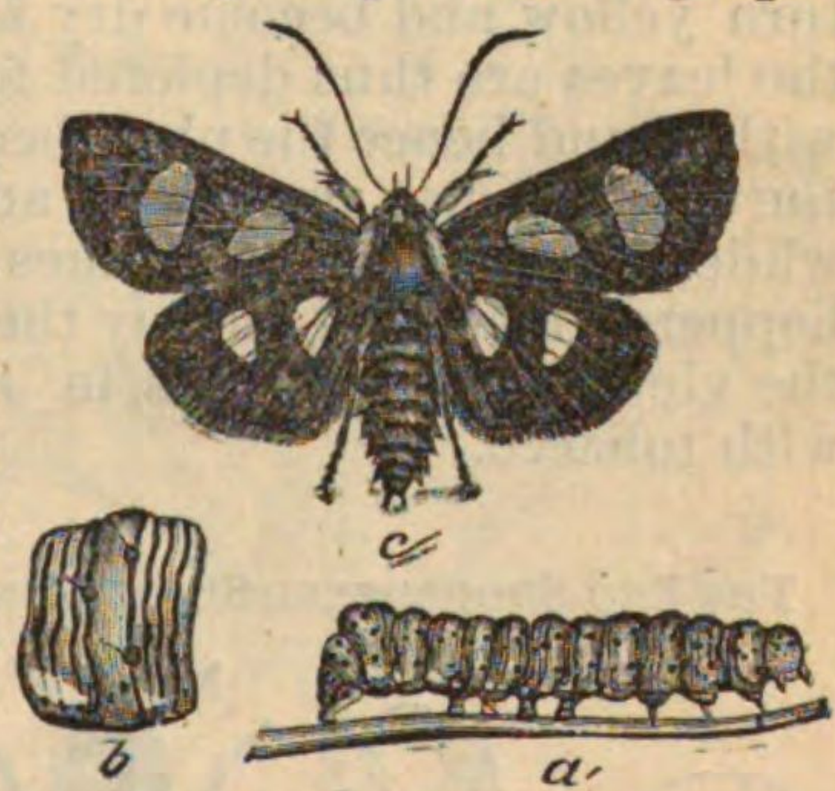


FIG. 53.—The Grape Forester. *a*, caterpillar; *b*, side view of a segment enlarged.

THE GRAPE-VINE COLASPIS, *Colaspis flanda*, Lay. (Fig. 54).—Eating the terminal buds and young leaves, also riddling the leaves. A cream-colored and black beetle.

This little beetle is one of the worst of the forty or fifty different insect-enemies of the grape-vine. The beetle ranges from New York to Illinois and Missouri. It is cream-colored and black, with long club-shaped feelers nearly a fifth of an inch long; the head and prothoray are reddish-yellow, while the wing-covers are black. Hand-picking is the best remedy. The larva (Fig. 57 *a*) has been found by Professor Riley to feed on the roots of the strawberry. It transforms in the ground.

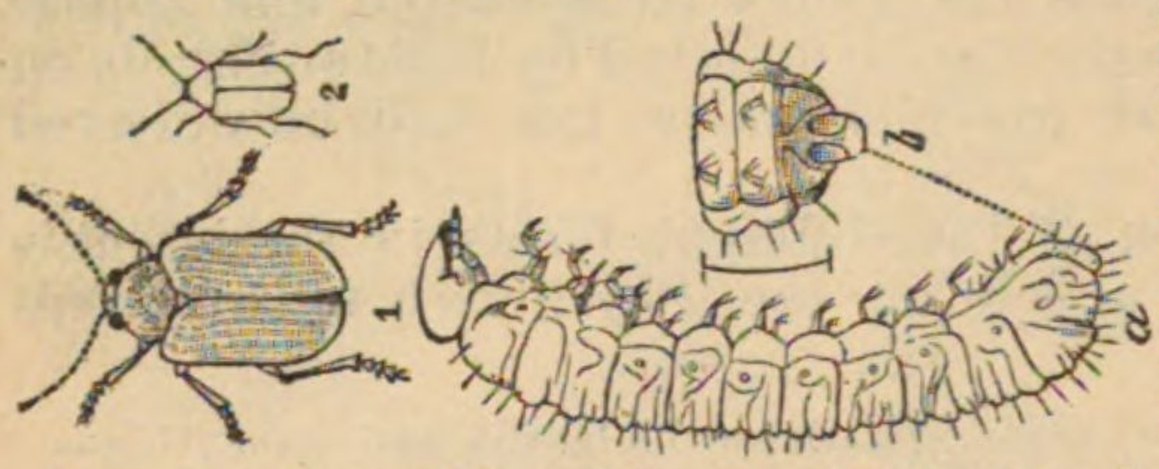


FIG. 54.—Grape-Vine *Colaspis*. 2 nat. size; 1, the same magnified; *a*, the larva; *b*, end of body enlarged. (After Riley.)

THE VINE-LEAF HOPPER, *Erythionenis vitis* Harris. (Fig. 55).—Swarming upon the leaves in August and early September; a small, pale yellow leaf-hopper, with two broad red bands on the wings, causing the leaves to wither.

This little insect, which I have seen abounding in the vineyard of the Massachusetts Agricultural College early in September, when the grapes were ripening, is pale yellow, with two broad red bands and a third dusky one at the apex. It is a little over a tenth of an inch long. It swarms on the leaves in August, puncturing them with its tiny beak and drawing out the sap until the leaves turn yellow and become dry and stiff. The young appear in June, and the leaves are thus depleted for a period of nearly three months. They wither, and hence the plant becomes enfeebled, little new wood is formed, the canes do not ripen well, and the fruit is stunted and easily mildews, while in a few years the vines become exhausted and barren. The leaf-hoppers hibernate, and lay their eggs in the spring. As a remedy, wash the vines with soap-suds in June, and, if possible, fumigate the leaves with tobacco.

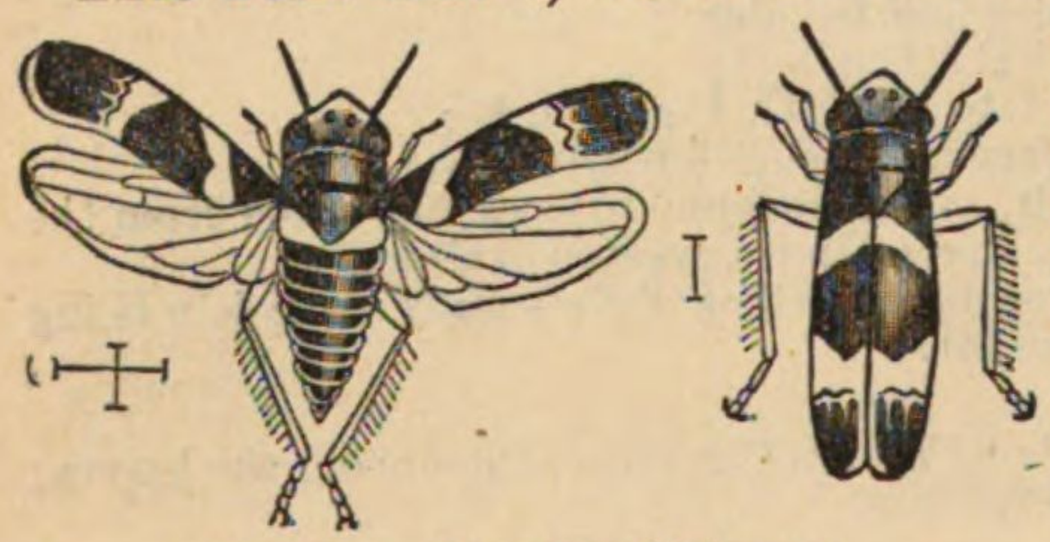


FIG. 55.—Vine-Leaf-Hopper.

THE RED-SHOULDERED SINOXYLON, *Sinoxylon basillare* Lay. (Fig. 56).—Boring under the bark and into the middle of grape-stems; a short, thick maggot.

This blight insect sometimes bores under the bark of the grape, as well as in the heart of grape-stems. It also tunnels in apple-trees and in the shag-bark hickory, boring holes straight toward the heart of the tree, and changing to the pupa state at the inner ends of their burrows. (Harris.) As a remedy, burn the infested twigs or stems.

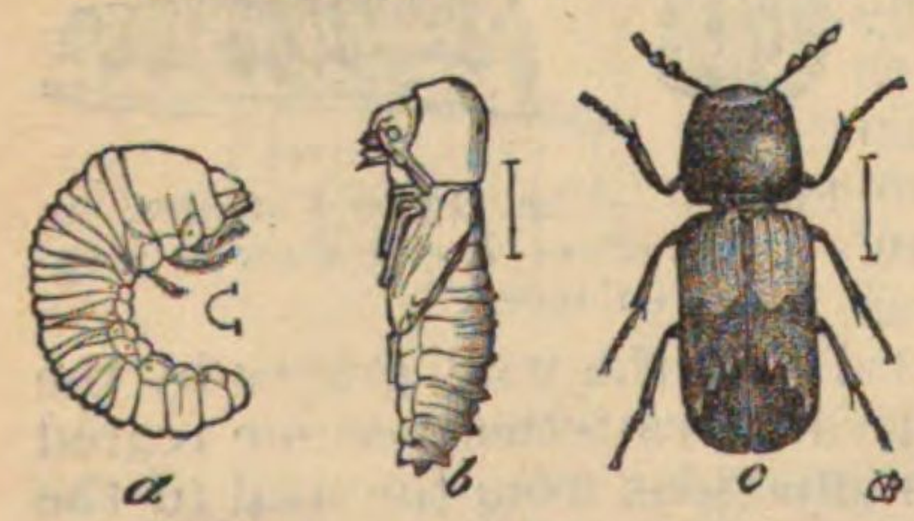


FIG. 56.—Red shouldered *Sinoxylon*. *a*, larva; *b*, pupa; *c*, beetle. (After Riley.)

INJURING THE CURRANT.

THE EUROPEAN CURRANT SAW-FLY, *Nematus ventricosus* Klug. (Figs. 57–59).—Devouring the leaves from June until August; a green false caterpillar, changing to a pale honey-brown saw-fly.

This destructive insect was imported from Europe into nurseries at Toronto, Canada, and was detected at Rochester, N. Y., during the year 1857. It seems since that time to have spread westward and eastward, arriving in Eastern Massachusetts about 1865, as I am informed by Mr. F. G. Sanborn. For eight seasons past it has been very destructive in gardens in Massachusetts as well as in Illinois and Michigan, where it seems destined to spread farther west.

The parent of this worm is a saw-fly, so named from bearing a saw-like sting, or ovipositor, with which it pierces the leaves or stalks of plants, cutting a gash, in which it deposits an egg, the egg passing out from the ovary through the oviduct, and thence through the blades of the ovipositor into the wound made in the plant. While most of the members of this family cut a gash in the leaf, into which an egg is pushed, a few, as in the present insect, simply place them on the under surface of the leaf, as seen in Fig. 59. (1.) The fly has four wings, and belongs to the same group of insects (*Hymenoptera*) that comprises the bee, wasp, and ichneumon-fly.

The following account of its habits is taken from the writer's Guide to the Study of Insects: "There are about fifty species of *Nematus* in this country, of which the most injurious one, the gooseberry saw-fly, has been brought from Europe. Professor Winchell, who has studied this insect in Ann Arbor, Mich., where it has been very destructive, observed the female on the 16th of June, while depositing her cylindrical, whitish, and transparent eggs in regular rows along the under side of the veins of the leaves, at the rate of about one in forty-five seconds. The embryo escapes from the egg in four days. It feeds, molts, and burrows into the ground within a period of eight days. It remains thirteen days in the ground, being most of the time in the pupa state, while the fly lives nine days. The first brood of worms appeared May 21; the second brood, June 25." Fig. 57 shows the eggs deposited along the under side of the midribs of the leaf; 2, the holes bored by the very young larvæ; and, 3, those eaten by the larger worms.

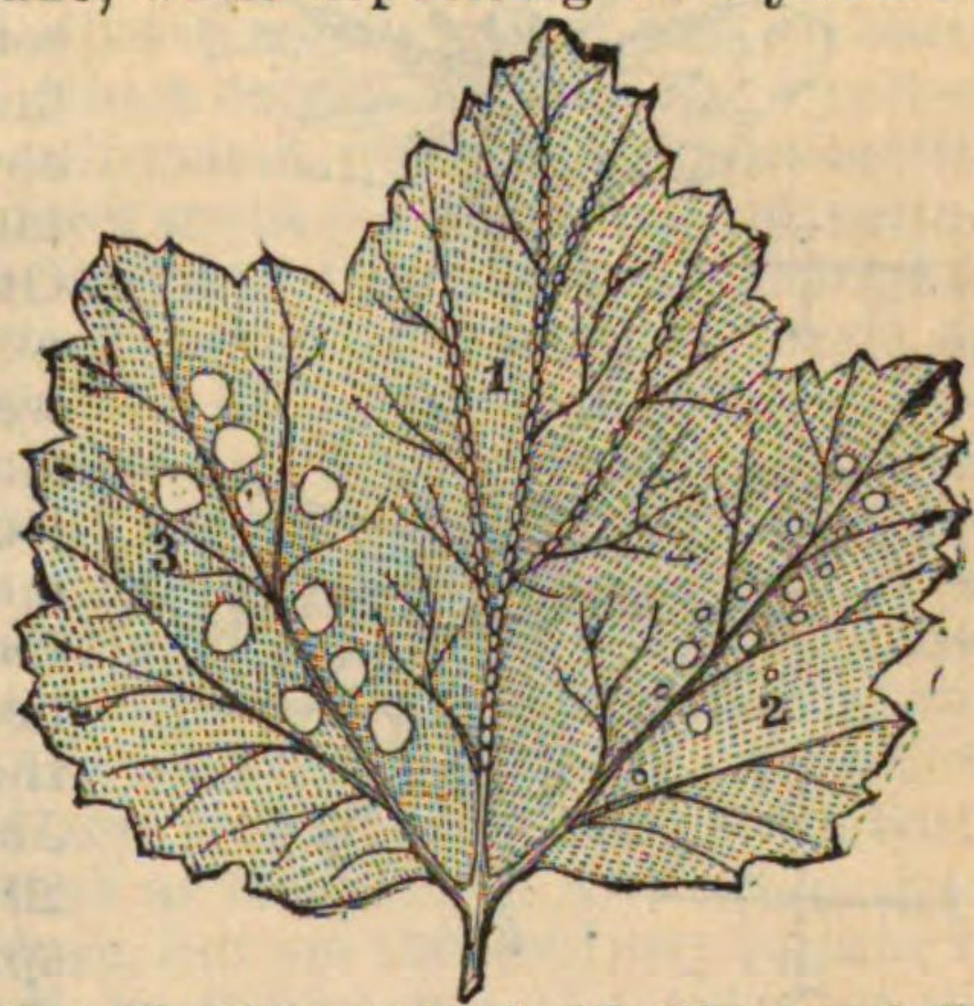


FIG. 57.—Currant-leaf with (1) eggs; 2, 3, holes eaten by the larvæ. (After Riley.)

Fig. 58 (*a*, enlarged) represents the worm when fully grown. It is then cylindrical, pale green, with a pale-green head, with the segment next behind the head, and the third segment from the end of the body, together with the last or anal segment yellow; the 16 false or abdominal legs are also yellow; the six thoracic legs are horn-colored. The body is transversely wrinkled, especially on the back, and is slightly hairy. The eyes are black, and the jaws (mandibles) are black, and on the inner side of the edge reddish. It is about three-quarters of an inch in length.

Previous to the last molt, however, and before it had gained its full size, preparatory to passing into the adult or winged condition, the body is covered with black tubercles; from each of which arises a stiff black hair. There is also a supraanal or dorsal black patch on the last segment of the body, from which arises a pair of black spines. On the back of the false caterpillar the tubercles become smooth and transversely oval, and arranged in two regular rows. Moreover, a still more important characteristic of the worm in this stage is the jet-black head, which in the fully-grown insect is pale pea-green.

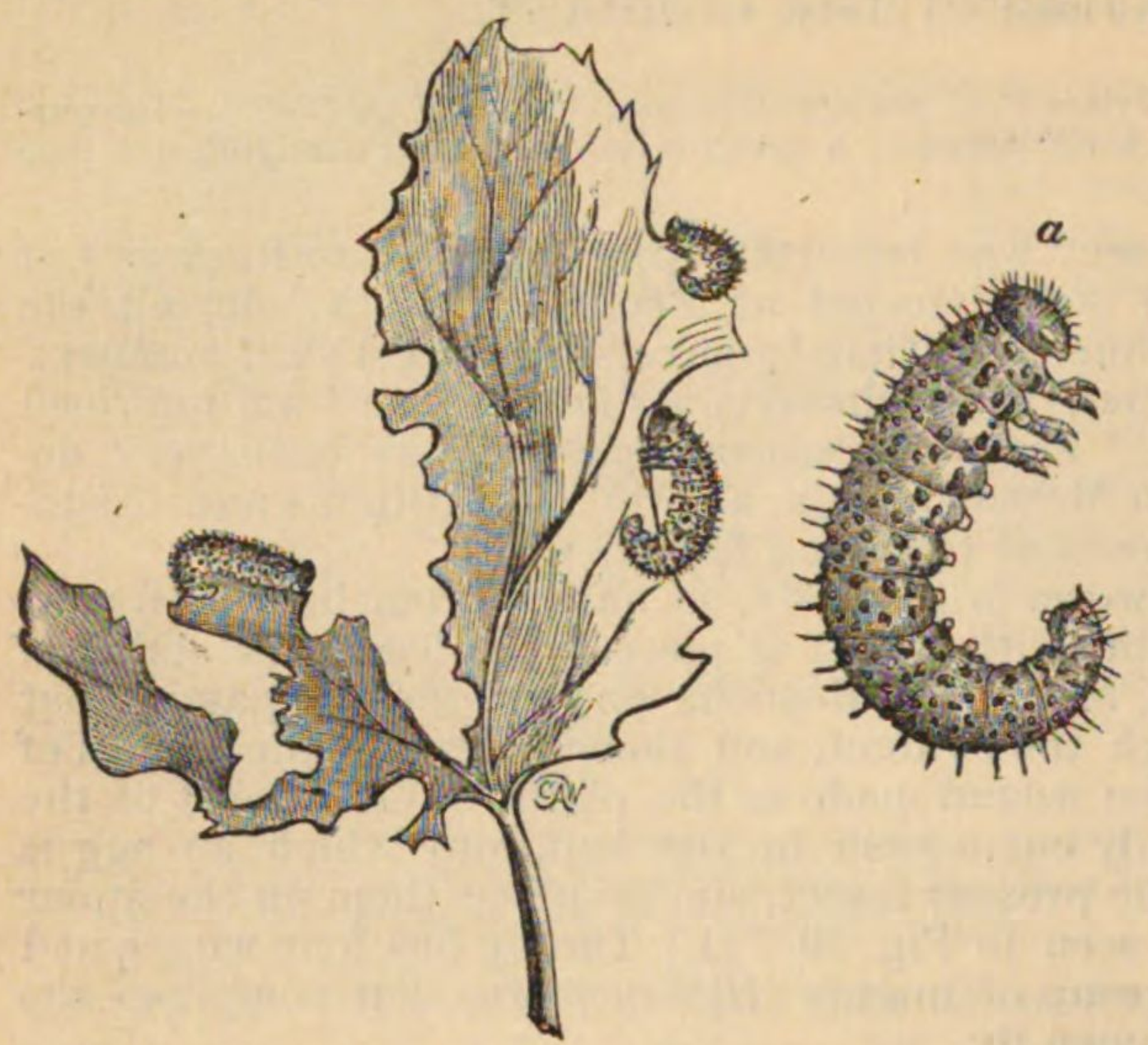


Fig. 58.—Currant saw-fly larva, natural size; *a*, enlarged.

In Salem, my attention was drawn to the ravages of this worm by Dr. William Mack, who found them feeding on the currants in his garden June 8. At this time they were spinning their cocoons, which were of silk, tough, dense, like parchment, and at first green, then becoming blackish, and covered with particles of dirt, and attached to the leaves in the breeding-box. Out of doors they may be found the first week in June, and again during the first week in July among the leaves and stalks on the bushes, or among the leaves lying on the ground, or perhaps more frequently a little under the surface of the ground. Here they remain between two and three weeks in June, the adult flies (in Salem) appearing June 25. At nearly the same date (June 29) the worms of the second brood were spinning their cocoons. These cocoons (belonging to the second brood) remain under ground or on the leaves about the roots through the winter, the flies appearing in the spring and laying their eggs as soon as the leaves unfold.

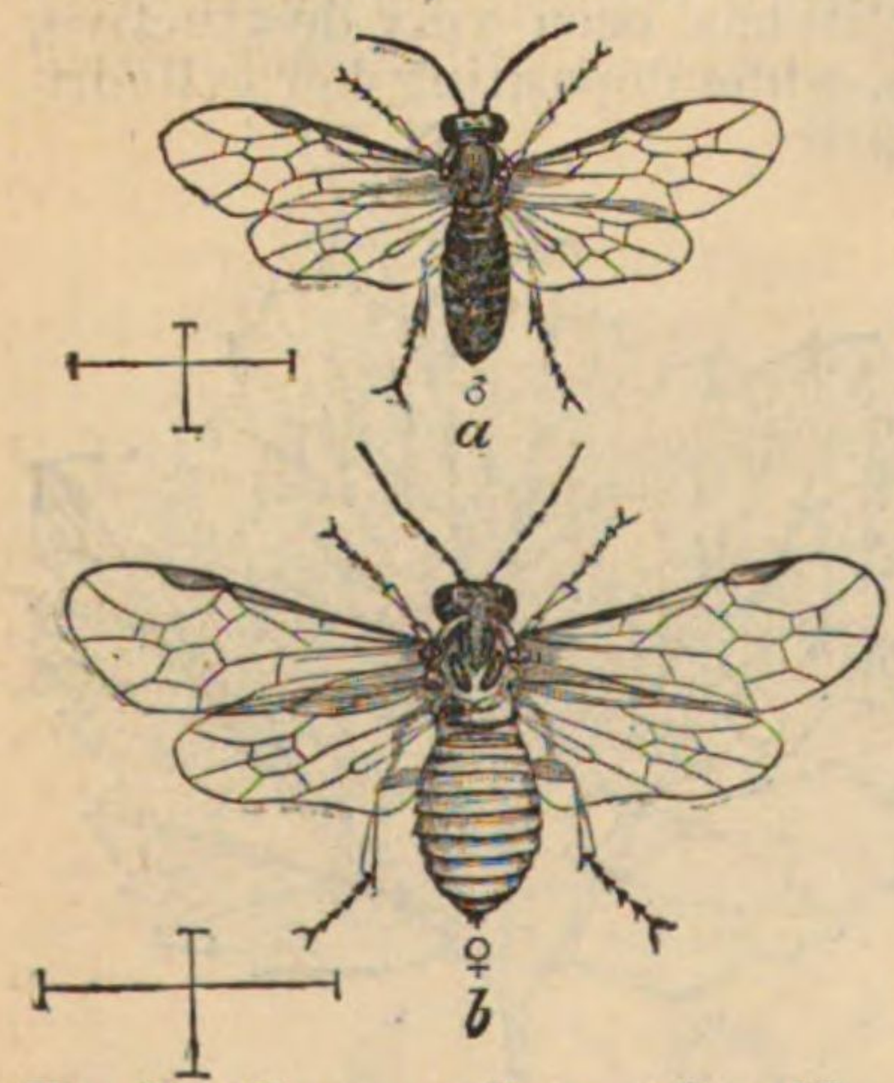


Fig. 59.—European Currant Saw-Fly. *a*, male. *b*, female. (After Riley.)

Not having specimens of both sexes of this saw-fly at hand, I compile the following description (often using their own words) from Messrs. Walsh and Riley's account in the American Entomologist, vol. ii, p. 16, from which these illustrations (Fig. 59 *a*, *b*) are taken.

The female (Fig. 59 *b*) is a quarter of an inch long ($\frac{22}{100}$–$\frac{28}{100}$), and is of a bright honey-yellow color. The head is black, with all the parts between and below the origin of the antennæ, except the tip of the

mandibles (jaws), dull honey-yellow. The antennæ are brown-black, often tinged with reddish above, except toward the base, and beneath entirely dull reddish, except the two basal joints. They are four-fifths as long as the body; the third joint, when viewed sideways, is four times as long as wide; the third, fourth, and fifth joints are equal in length, the remaining joints slowly diminishing in length. On the thorax are four conspicuous black spots and other smaller ones. The legs are bright honey-yellow; the basal or hip-joints (coxæ and trochanters) whitish, while the extreme tips of the hind shanks (tibiæ) and the whole of the hind toe-joints (tarsi) are blackish brown. The wings are glossy, with dark veins, and expand a little over half an inch.

The male (Fig. 59 *a*) is rather smaller ($\frac{20}{100}$ inch in length), and is black. The head is dull honey-yellow. The antennæ are brown-black, often a little reddish beneath, except toward the base; they are as long as the body, and while longer than in the female, are also somewhat flattened out. The thorax has the wing-scales and the prothorax, or collar, honey-yellow. The under side and tip of the abdomen are honey-yellow.

The injury done to currant-bushes during the past year was very great. In June, we saw them in great numbers in a garden at Lawrence, where they had stripped the bushes, eating the leaves down to the leaf-stalk, myriads clustering upon the branches. The birds evidently do not feed upon them, and thus, in dealing with this insect, we are deprived of one of the most powerful agencies in nature for restraining a superabundance of insect-life.

As this is an important and practical subject, let us digress for a moment to notice some facts brought out by Mr. J. J. Weir, of the London Entomological Society on the insects that seem distasteful to birds. He finds by caging up birds whose food is of a mixed character (purely insect-eating birds could not be kept alive in confinement), that all hairy caterpillars were uniformly uneaten. Such caterpillars are the "yellow bears" (*Arctia* and *Spilosoma*), the salt-marsh caterpillars (*Leucarctia acræa*), and the caterpillar of the Vaporer moth (Orgyia), and the spring larvæ of butterflies; with these may perhaps be classed the European currant saw-fly. He was disposed to consider that the "flavor of all these caterpillars is nauseous, and not that the mechanical troublesome, ness of the hairs prevents their being eaten. Larvæ which spin webs- and are gregarious, are eaten by birds, but not with avidity; they appear very much to dislike the web sticking to their beaks, and those completely concealed in the web are left unmolested. When branches covered with the web of *Hyponomenta evonymella* (a little moth of the *Tinea* family) were introduced into the aviary, those larvæ only which ventured beyond the protection of the web were eaten." "Smooth-skinned, gaily-colored caterpillars (such as the currant *Abraxas*, or span worm), which never conceal themselves, but on the contrary appear to court observation", were not touched by the birds. He states, on the other hand, that "all caterpillars whose habits are nocturnal, and are dull-colored, with fleshy bodies and smooth skins, are eaten with the greatest avidity. Every species of green caterpillar is also much relished. All *Geometræ*, whose larvæ resemble twigs, as they stand out from the plant on their anal prolegs, are invariably eaten." Mr. A. G. Butler, of London, has also found that frogs and spiders will not eat the same larvæ rejected by birds, the frogs having an especial aversion to the currant span-worms (*Abraxas* and *Halia*).

The natural enemies of the currant saw-fly are three kinds of ichneumon-flies, of which one is a minute egg-parasite. Mr. Lintner, of New

York, states that of fifty eggs laid by the parent saw-fly, only four or five hatched out the currant-worm. We see, then, that though the birds apparently destroy none, an immense number are carried off, even before they have a chance of doing any mischief, by minute insects of their own order.

One of the best remedies next to picking them off by hand, and which is really the most practicable method of getting rid of them, is to dust powdered white hellebore over the bushes, by sprinkling it from a muslin bag tied to a stick, as it otherwise excites violent sneezing. Used in this small quantity it is not poisonous. This is the remedy used with most success in the West, and recommended by Messrs. Walsh and Riley. I have used it with good success in my own garden, and it is a thorough remedy if thoroughly and persistently applied. Dr. W. Mack, of Salem, tells me that he has used a solution, consisting of a pound of copperas to six gallons of water, with much success. It blackens the leaves, but does not injure them permanently.

Dr. E. Worcester, of Waltham, according to the Boston Journal of Chemistry, finds that this worm "may be fully and almost immediately destroyed by the use of carbolate of lime. The doctor tried the powder in many instances during the past summer, and found that while it was fully as effective as hellebore, it was less disagreeable, less costly, and perfectly safe. The method of using it is to sprinkle it over the vines as soon as the worm makes its appearance, bringing it well in contact with the leaves, and soon the insect is destroyed. It will need but two or three applications, and the work is done."

This worm attacks the gooseberry as well as the currant, though in Massachusetts its ravages have been more confined to the latter shrub. As a preventive measure against its further spread, in buying or transporting gooseberry and currant bushes, Walsh recommends that the roots be carefully cleaned of dirt, so that the cocoons may not be carried from one.garden or nursery to another.

THE NATIVE CURRANT SAW-FLY, *Pristophora grossulanæ* Walsh.—As this species may be confounded with the European saw-fly, though belonging to a different genus (*Pristiphora*), the following brief account of it is extracted from my Guide to the Study of Insects:

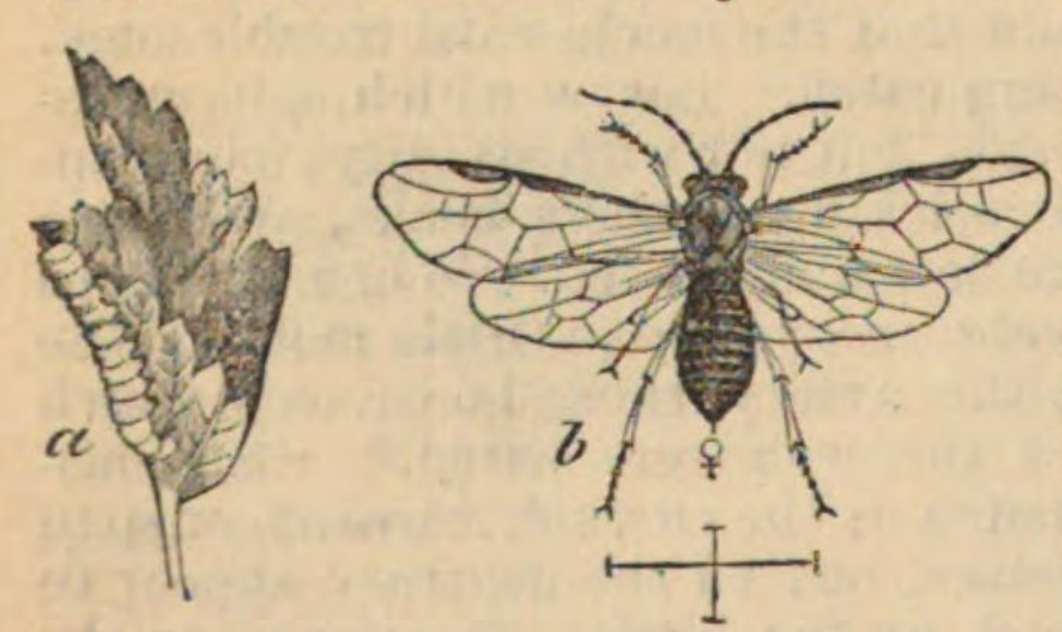


FIG. 60.—Native Currant Saw-Fly. *a*, larva; *b*, female.

This saw-fly (Fig. 60 *a*, larva; *b*, female, from the "American Entomologist"; *P. grossulariæ* of Walsh) "is a widely diffused species in the Northern and Western States, and injures the currant and gooseberry. The female fly is shining black, while the head is dull yellow, and the legs are honey-yellow, with the tips of the six tarsi, and sometimes the extreme tips of the hinder tibiæ, and of the tarsal joints, pale dusky for a quarter of their length. The wings are partly hyaline, with black veins, a honey-yellow costa, and a dusky stigma, edged with honey-yellow. The male differs a little in having black coxæ. Mr. Walsh states that the larva is a pale grass-green worm, half an inch long, with a black head, which becomes green after the last molt, but with a lateral brown stripe meeting with the opposite one on the top of the head, where it is more or less confluent; and a central brown-black spot on its face. It appears the last of June and early in July, and a

second brood in August. They spin their cocoons on the bushes on which they feed, and the fly appears in two or three weeks, the specimens reared by him flying on the 26th of August." This worm may at once be distinguished from the imported currant-worm by the absence of the minute black warts that cover the body of the latter. The same remedies should be used for this worm as are recommended for the preceding insect.

THE CURRANT SPAN-WORM, *Eufitchia ribearia* Fitch. (Fig. 61, moth; Fig. 62, 1, 2, caterpillar; 3, pupa, from the "American Entomologist.")—Devouring the leaves; a span-worm, about an inch long, bright yellow, spotted, being nut-black.

Many persons, in speaking of the "currant-worm," confound the caterpillar-like saw-fly larva with the well-known geometer caterpillar, which is a native species, and was long since described by Dr. Fitch, under the name of *Abraxas ribearia*. As soon as the leaves of the currant are fairly expanded, late in May or early in June, the young caterpillars, scarcely thicker than a horse-hair, may be found eating little holes in them. In about three weeks after hatching it becomes fully grown, being about an inch long, and bright-yellow in color, the body being covered with large, black dots. The chrysalis is shining reddish-brown, about half an inch long, and may be found late in June, either upon the ground or just under the surface. In two weeks after entering the chrysalis state the moth may be observed flying about the garden or resting upon the leaves during cloudy weather. The moth is yellow ochreous, with dark, often nearly transparent, blotches on the wings. It is not easily mistaken for any other moth. Mr. Riley, in an article on this insect in the "American Entomologist," states that by sprinkling powdered hellebore upon the leaves, or applying a solution of eight or twelve ounces to a bucketful of water, the caterpillars will be killed. Hand-picking assiduously followed up, and a vigorous shaking of the bushes over a sheet or a newspaper, repeated twice a day, will keep the insect within moderate bounds.

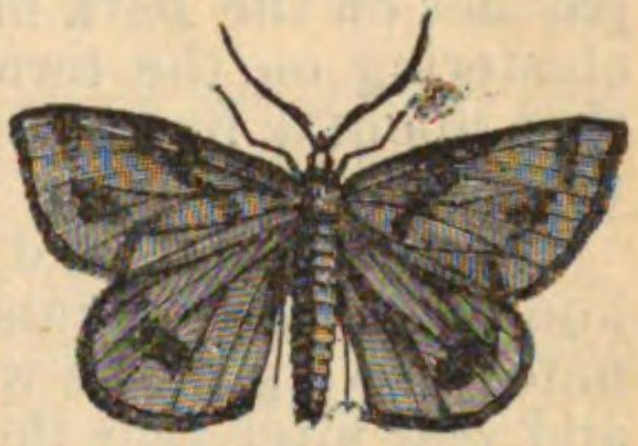


FIG. 61.—Moth of Currant.

FIG. 62.—Currant Span-Worm. (After Riley.)

INSECTS INJURING THE APPLE.

THE CANKER-WORM, *Anisopteryx vernata* Peck, and A. *autumnata* Packard. (Plate LXIX Figs. 1–4.)—Devouring the leaves; a dark-striped span-worm, varying in color to pale green, transforming in the earth, and with wingless females and winged males.

Next to the apple-tree borer, which has almost cut off the apple-crop of the Eastern States in certain localities, the canker-worm, always local in its distribution, is the most injurious. Originally confined, as

an injurious insect, to Eastern Massachusetts and Connecticut, it is now injurious in Illinois and Missouri. It must originally, at least *A. vernata*, have occurred all over the United States east of the Mississippi, as I have received it from Texas. It may possibly be introduced into the Territories, and therefore I refer to it simply in this connection.

Let us now examine the life-history of a canker-worm. And here we will confine ourselves to a single species, the *Anisopteryx vernata* of Peck, which appears in the spring, not touching at present on the autumnal species. About the 1st of May, at the time when the leaves of the apple are unfolding, the young canker-worms break through the eggs, which have been laid earlier in the season, in March and April, in patches on the bark of the trunk and limbs. They may be soon found clustering on the terminal buds and partly unfolded leaves, and are then about a line in length, and not much thicker than a bit of thick thread.

How they grow and devour every green thing on the tree is too well known to the fruit-raisers in the eastern part of Massachusetts. Fortunately, owing to the want of wings, the female is exceedingly sedentary, and year after year the trees of particular orchards and towns are defoliated and turned brown, while adjoining orchards and towns scarcely suffer. By the 20th of June, in Essex County, Massachusetts, the orchard looks as if a fire had run through it. At that date the worms are fully fed, and they then descend to the ground, letting themselves down by a silken thread. At this time I have destroyed thousands by jarring the tree and collecting those which fall down. I have watched old and young robins busily engaged in eating them, and from the number of toads in my garden, gathered about under the trees, I feel confident that they eat multitudes of them.

The worms at once enter the ground, change to chrysalids several inches below the surface, near the trunk of the tree, and there remain until the early days of March and April, when the wingless females ascend the trees, and the winged males may be seen fluttering about.

I took pains one spring, in the middle of April, to count the number of these moths on my apple-trees, fourteen in number, averaging from 6 to 7 inches in thickness, besides three elms. They were more abundant on the apple-trees than the elms. But on those seventeen trees there were counted, adhering mostly to the tarred paper, 1,000 males and 200 females. The spring of 1875 was cold and backward, and few moths were seen before this date. From these data we can ascertain approximately the relative numerical proportions between the sexes, which seems to approximate five males to one female.

The species I have referred to is the spring moth, the *Anisopteryx vernata* of Peck, but not of Harris. The other species is much less abundant in the adult condition, and only appears in the autumn. The wings are thicker than those of *vernata*, and the caterpillar has an additional pair of prop-legs, though so short as to be useless. I find that most of the damage is done by the caterpillars of *vernata*. On June 15, 1875, I collected 557 caterpillars from the apple-trees in my garden. Of these 520 were *vernata*, and 27 were the young of the autumn species. Peck, in his account published in 1795, states that *vernata* does the principal damage.

As for remedies, the use of printer's ink laid on tarred paper is the cheapest, though the ink should be applied every day or two. The use of tin troughs of oil surrounding the tree is almost sure to stop the ascent of the females, while wooden troughs of oil built around the bottom of the trunk is almost equally efficacious. Care and attention, and,

above all, co-operation among those suffering from these worms, would enable us to check their ravages.

Plate LXVIX, Fig. 1, *a*, represents the caterpillar of *vernata; b*, egg; *c*, *d*, side and dorsal view of a segment of the caterpillar. Fig. 2, *a*, the male moth; *b*, the wingless female; *c*, three joints of the antenna; *d*, dorsal view of an abdominal segment. Figs. 3 and 4 the different stages of the autumnal species (*A. autumnata*).

THE AMERICAN TENT-CATERPILLAR, *Clisiocampa americana* Harris. (Plate LXIX, Figs. 5, 6.)—Devouring the foliage and forming conspicuous tent-like webs or nests in the forks of the branches; a large, hairy caterpillar with a dorsal white stripe and numerous fine, wrinkled black lines on a yellow ground, united below into a common black band, with a blue spot on the side of each ring.

At the same time that the canker-worms are breaking out of their egg-shells, the young tent-caterpillars are following suit. This occurs usually about the 1st of May, in the region of Boston, or a month or six weeks earlier in the latitude of Saint Louis, just as the leaves are unfolding. At this time, if one will examine closely the conspicuous bunches of eggs on the twigs of the tree, he may be able to see the little caterpillars clustering about on the outside of the egg-mass. When hatched, they have large heads, and the body is provided with long, scattered hairs. They at once betake themselves to the opening buds, congregating at noon-time, when the sun is hot among the axils of the branches, there forming a tent of silk for protection from the sun and rain. As they increase in size, they make extended journeys over different branches, laying pathways of silk wherever they go. The tent or nest increases in size until it becomes the conspicuous, but by no means ornamental, object so noticeable on the grounds of slovenly farmers early in June. The caterpillars become fully grown by the middle of June. Then they spin dense, tough, white cocoons under loose bark, or under boards and rails of fences, and the moth appears about the 1st of July.

I once experimented with a worm to see how persevering it would be in spinning its cocoon. After one cocoon was finished I removed it, when by another day a new one was spun like the other. Upon my removing this, it spun a third one which was thin and slight, the supply of silk having been exhausted. The silk is secreted by two glands one-half longer than the body when drawn out, but which are folded up beneath the digestive canal, and open out on the under lip. The silk is fluid, becoming solid on exposure to the air.

The American tent-caterpillar is about two inches in length, with long, rather dense hairs. Along the back runs a white stripe, accompanied by numerous fine, wrinkled black lines on a yellow ground, united below into a common black line. On the side of each segment of the body is a conspicuous blue spot.

The moths hide by day about the garden, and when the lamps are lighted, in they dart and tumble about on the table under the light, in an insensate way, as if frightened out of their wits. So peculiar is their mode of entering a lighted room, that one can usually tell what moth is coming by its peculiar, noisy mode of entrance. The moth is reddish-brown, very thick-bodied, clothed in a thick coat of long hairs, and with short, broad, strong wings, as it flies swiftly. It is reddish-brown, with two oblique, dirty-white lines on the fore wings, which expand when outstretched, about an inch and a half. Early in July the female lays her eggs, in bunches of from three hundred to four hundred. They are placed side by side, in a mass surrounding the twigs (Plate LXIX, Fig. 5, *c*), and after they are thus stuck on so as to surround the branch like

a collar, the entire mass is covered over with a gummy secretion, which hardens, and serves as a protection to the eggs.

Remedies.—In the early spring as well as late autumn the bunches of eggs should be picked off and burned. When the tents are formed in June the nest should be removed with a mop dipped in oil or kerosene, at noon-time, when the caterpillars are in the tent. By discharging a gun close to the nest it can be destroyed with a small charge of powder.

Plate LXIX, Fig. 7, represents the caterpillar of *Clisiocampa disstria* Hübner (*sylvatica* Harris), which rarely occurs on apple-trees, being more common on the oak. It is a light blue, with a dorsal rim of eleven white oval spots. The moth, with the eggs, is represented at Fig. 8. There are two species of *Clisiocampa* in California (*C. californica* Pack., and *C. constrictu* Stretch), and one is troublesome to apple-trees at Salt City, Mr. Barfort tells me, which may in time leave the oak on which it feeds and attack the apple. Both of the eastern tent-caterpillars origna ly fed on the oak.

THE FALL WEB-WORM, *Hyphantria textor* Harris. (Fig. 63.)—Forming large webs on fruit and forest trees in August; a hairy, slender, greenish-yellow caterpillar dotted with black, changing to a snow-white unspotted moth.

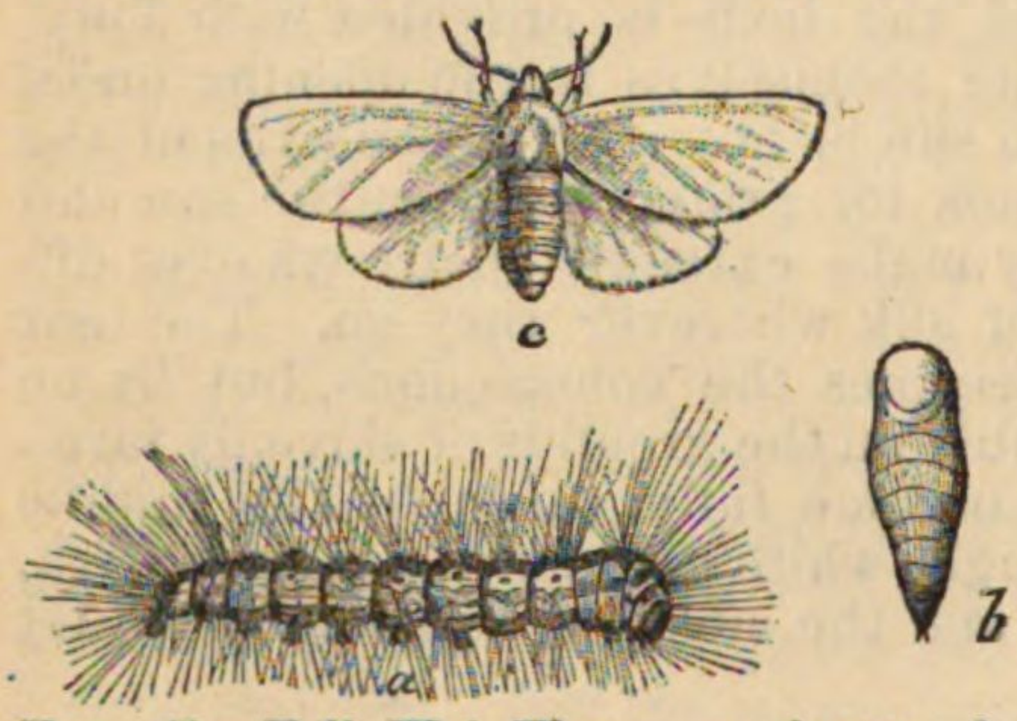


FIG. 63.—Fall Web-Worm. *a*, larva; *b*, chrysalis; *c*, moth. (After Riley.)

This common and annoying caterpillar is universally abundant, weaving its conspicuous web or tent-like structure on the branches of the apple, pear, and cherry, etc., in August, the worms remaining about until the leaves are nearly ready to fall. They usually eat the leaves on one entire branch and then pass to the next, tying the leaves together with silken threads. They are easily exterminated by hand-picking.

THE CODDLING MOTH, *Carpocapsa pomonella* Linn. (Plate LXIX, Fig. 9.)—Eating holes in apples, causing them to fall prematurely; a small flesh-colored worm, transforming into a small gray moth.

This moth, which is such a universal pest in the Eastern States, has for five years past, Mr. Barfort tells me, been injurious to the apples in Salt Lake City. Indeed, it is the only considerable pest of the apple in the Territory, but one that attracts a good deal of attention. Mr. Henry Edwards, of San Francisco, writes me that it has not yet occurred in California.

The moth lays usually one egg on the blossom end of the fruit early in summer, and the caterpillar hatches in a few days, burrowing directly into the core of the forming fruit. It attains its full size, becoming fully fed, in about three weeks, when the apple drops to the ground, and the larva transforms in a thin or sometimes quite thick cocoon in crevices in the bark of the tree, etc., and in a few days after another brood of moths appear, though most of them, as I have found in Maine, remain in their cocoons through the winter in the caterpillar state. In this condition I have found them under the loosened bark early in May. Many of the worms, Dr. Le Barm, in his Illinois report, says one-half, instead of waiting for the immature apples to fall, desert the apple and let themselves down by the web or walk down the trunk of the trees. The moth is gray, with numerous darker, transverse lines, and with a

curved black line before the ocellated patch on the inner angle, which line is edged with a coppery tint. Plate LXIX, Fig. 9, represents the caterpillar, with the worm-eaten apple, the cocoon (*i*), and the chrysalis and moth.

Remedies.—This troublesome pest may be partially destroyed by gathering the "windfalls," though the larva often deserts the worm-eaten apples before it falls. The best remedy is that suggested by Dr. Trimble, who binds bands of hay about the trees from July until the middle of September. The larvæ crawl under these bands and there spin their silken cocoons, when every fortnight the bands can be removed and the worms destroyed. Dr. Le Barm recommends for Northern Illinois that the bandages be in place a month after the blooming of the trees; that they be examined seven weeks after the falling of the blossoms; that three subsequent examinations be made at intervals of twelve days, and a final one after the leaves of the tree have fallen. In the latitude of Saint Louis, Mr. Riley suggests that the first examination be made not later than six weeks after the falling of the blossoms; and that four subsequent examinations, at intervals of twelve days, be made between it and the final one in the autumn when the apples are gathered.

THE APPLE-WEEVIL, *Anthonomus quadrigibbus* Say. (Figs. 64, 65.)—Boring in the apple; a long, slender maggot, transforming in the apple into a weevil, with a snout nearly as long as the body.

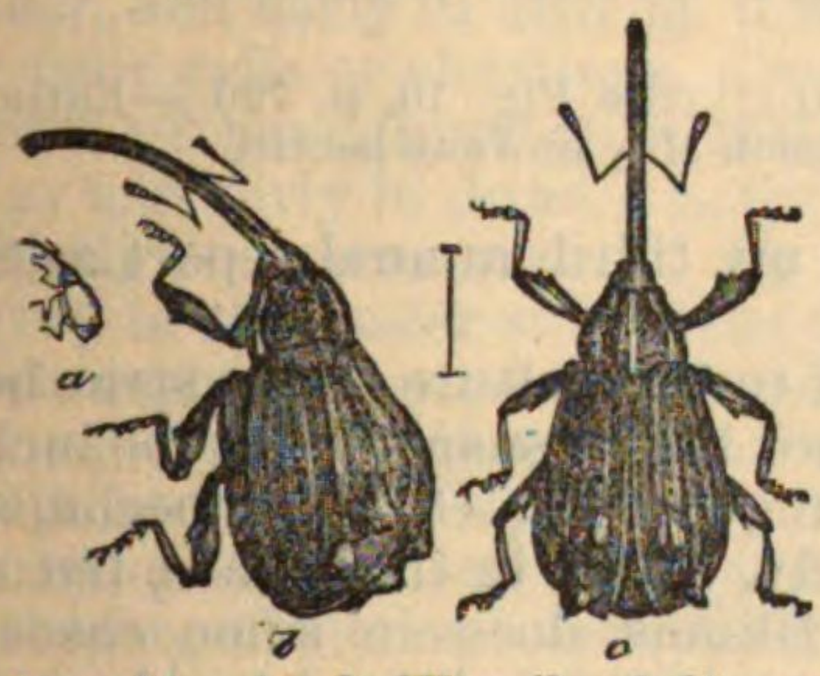


FIG. 64.—Apple-Weevil, adult. *a*, nat. size; *b*, *c*, enlarged. (After Riley.)

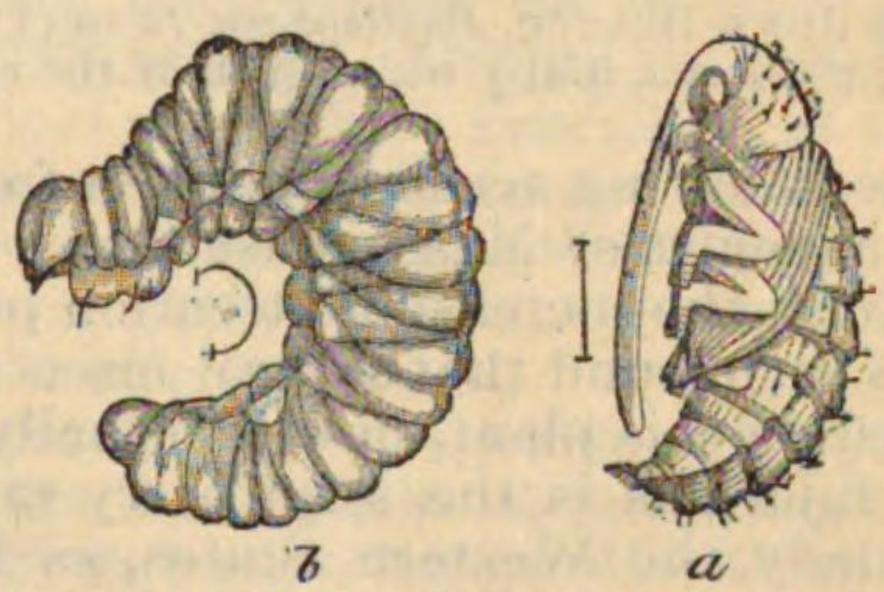


FIG. 65.—Apple-Weevil. *a*, pupa; *b*, maggot; both enlarged.

This weevil, which need not be confounded with the plum-weevil, is smaller, and has a longer beak. With its long snout it drills holes into the apple, deposits an egg, and the grub goes right to the heart of the apple, feeding around the core for nearly a month, when it transforms in the fruit, which does not fall. It remains two or three weeks in the pupa state, not leaving the fruit until it becomes a beetle.—(Riley.)

INSECTS AFFECTING THE PLUM.

THE PLUM-WEEVIL, *Conotrachelus nenuphar* Herbst.—Puncturing the young fruit; a weevil, like a dried plum-bud in general appearance, whose grub in the plum causes the fruit to prematurely fall.

The plum-weevil has nearly cut off the fruit in the Eastern States, so that comparatively little is raised. The following condensed account is taken from "The Guide to the Study of Insects:" "This beetle is a short, stout, thick weevil, and the snout is curved, rather longer than the thorax, and bent on the chest when at rest. It is dark brown, spotted with white, ochre-yellow and black, and the surface is rough, from which the beetle, as Harris says, looks like a dried bud when shaken from the tree. When the fruit is set, the beetles sting the

plums, and sometimes apples and peaches, with their snouts, making a curved incision, in which a single egg is deposited. Mr. F. C. Hill shows that the curculio makes the crescent-shaped cut after the egg is pushed in, 'so as to undermine the egg, and leave it in a kind of flap formed by the little piece of the flesh of the fruit which she has undermined. Can her object be to wilt the piece around the egg, and prevent the growing fruit from crushing it?'—(Practical Entomologist, Vol. ii, p. 115.) The grub hatched therefrom is a little footless, fleshy white grub, with a distinct round light-brown head. The imitation set up by these larvæ causes the fruit to drop before it is of full size, with the lava still within. Now full-fed, it burrows directly into the ground and transforms during the last of the summer. In three weeks it becomes a beetle. It also attacks other garden-fruits, such as the cherry, peach, and quince.

Remedy.—The best remedy is jarring the trees, and catching the larvæ in sheets and burning them. Dr. Hall's "curculio catcher" is an excellent invention for destroying these insects; it consists of a large inverted white umbrella, fixed upon a large wheelbarrow, split in front to receive the trunk of the tree, against which it is driven with force sufficient to jar the curculios from the tree into the umbrella.

INSECTS INJURING THE STRAWBERRY.

THE JUNE BEETLE, *Phyllophaga fusca* (Fröhl.). (See Fig. 10, p. 720.)—Eating the roots; the large, fleshy white grub of the common May or June beetle.

The following account is taken from my third annual report as State Entomologist of Massachusetts:

"With the increasing attention paid to the culture of the strawberry, it has been found that several insects not before suspected to be inclined to feed on this plant, now habitually frequent it. Of these perhaps the most injurious is the strawberry saw-fly, which in this State, but more especially the Western States, as in Illinois, does in some cases the most grievous damage. Then a few moths which have been known to feed on fruit-trees, the currant, etc., have transferred their affections to the strawberry; such are the apple-leaf-roller or *Tortrix*, the saffron measuring-moth (*Angerona crocataria*), and several other caterpillars found in the Western States, and described in the entomological reports of Messrs. Walsh and Riley, and also in 'Harris's Treatise on the Injurious Insects' of this State, and the reporter's 'Guide to the Study of Insects.'

"Next, however, in importance to the strawberry saw-fly (*Emphytus maculatus*), is one of the most common and familiar of all these insects which everywhere force their attention upon us. This is the common May beetle, June beetle or 'dor bug,' the American representative in its abundance and injurious qualities of the European cockchafer.

"Dr. Harris has given a brief sketch of its habits and transformations in his Treatise, and referred to the injury the grub, sometimes called 'white-worm,' does to the roots of grass, remarking that 'in many places the turf may be turned up like a carpet in consequence of the destruction of the roots.' He, however, does not say that it attacks the strawberry-roots, which it has for several years been known to do in gardens about Salem. My attention was especially called to its ravages by Mr. D. M. Balch, of Salem, who has lost many strawberry-plants by the white grub. It seemed evident that they were introduced in the manure placed around the roots, as during July and late in summer a

manure-heap near by swarmed with the well-known white grubs, in various stages of development, some apparently in the second year and others in the third year's growth. They eat the main roots of the plant, thus destroying one plant after another. From this it will be obvious that if we observe the plant to wilt and suddenly die, we may look for the white grub and at once kill it to prevent further ravages. It is evident, so large and voracious are these worms, that one plant would be a mere trifle to one of them.

"It also eats down in much the same manner young squash-plants, as I am told by Mr. C. A Putnam, of Salem, who has been obliged to plant the seed over once or twice. They attack young plants at the time when they have thrown out three or four leaves. It is obvious that in dealing with this destructive insect we must become familiar with its habits. Every one knows the larva or grub of this insect, so that a detailed description is not necessary. It is a large, soft-bodied, thick, white worm, nearly as large as the thumb. Its head is yellowish or pale horn-colored. Its skin is so thin and transparent that the air-vessels and viscera can be seen through it, while, though it has three pairs of legs, it is so gross and unwieldy that it lies, when dug out of its retreat, flat upon its side.

"How many years the grub lives before changing into the beetle we do not know, but probably at least three. It arrives at maturity in the autumn, and early in May in this state the chrysalis may be found in little rude cells or chambers about six inches under the mold, in which position we have found it in Maine late in May. During the latter part of May and early in June, *i. e.*, for about a month, it flies about at night, especially on warm nights. By day it hides in fruit and other trees, clinging to the under side of the leaves by its long, curved claws, which are admirably adapted for the purpose. Here it does at times much injury, especially, as Harris remarks, to cherry-trees.

"Where it lays its eggs is not definitely known, but it is probable that it burrows in the soil and there lays its eggs, as does the European cockchafer, of whose habits Harris gives a summary, and also the goldsmith beetle, of which we give an account farther on. Riley, however, says that 'soon after pairing, the female beetle creeps into the earth, especially wherever the soil is loose and rough, and after depositing her eggs to the number of forty or fifty, dies. These hatch in the course of a month, and, the grubs growing slowly, do not attain full size till the early spring of the third year, when they construct an ovoid chamber, lined with a gelatinous fluid, change into pupæ, and soon afterward into beetles.'

"In the autumn at the approach of cold it descends to a considerable depth below the surface to avoid the frost, probably about two feet below the usual depth at which the ground is frozen in the winter. At the approach of warm weather, however, it makes its way up near the surface, where it forms a slight cell by wriggling about, and then passes into the pupa state. It is said to sometimes pupate and appear in the winged state in the autumn.

"As to remedies against this grub, the careful gardener will in the first place destroy all those that he sees by crushing them to death. When the manure is spread over the strawberry-bed, he must watch it narrowly for the grubs so easily seen, and kill them. When a vine is seen to die down suddenly in summer he must then dig around the roots and search for them, and go over the bed carefully, even if help has to be employed. It is better to spend even much time and money for two or three years in succession, in endeavoring to exterminate these grubs,

than to yield passively to the scourge. The remarks of Mr. Lockwood, that we reprint in our account of the goldsmith beetle, are eminently practical as applied to this insect. As for special remedies, we have none to propose. Watchfulness and care in culture are better than any special nostrums.

"Undoubtedly the natural enemies of this grub are many, but we have no observations bearing on this point. A fungus attacks the grubs in certain seasons, often in considerable numbers. We have received specimens from Missouri of dead and dried grubs, with a long stem growing out from them, the result of the attacks of this fungus. It has been figured by Mr. Riley, who states that another fungus attacks this worm in Virginia. It is well known that caterpillars and even the common house-fly are sometimes attacked by a fungus which replaces the animal portion with its own vegetable substance.

"While many animals, such as skunks, moles, crows, etc., prey on the beetles, the only insect-enemy I have personally observed is the fierce carnivorous Calosoma beetle (*C. calidum*) which I have noticed on a blueberry-bush busily engaged in tearing open the hard, horny sides of one of these beetles, which was in vain struggling to escape; on taking up the May beetle a large hole had been eaten into its side, disclosing the viscera.

"Occasionally the beetles appear in immense numbers. It is then the duty of the agriculturist to pick them off the trees and burn them. If the French take the pains to practice hand-picking, as in one instance 'about eighty millions were collected and destroyed in a single portion of the Lower Seine' (Riley), our gardeners can afford to take similar pains.

"A description of the May beetle is scarcely necessary. Fig. 10 (p. 720) gives a good idea of its appearance and size. It is bay-colored, or chestnut and brown, with yellowish hairs beneath, and is nearly an inch in length. Its scientific name is *Lachnosterna fusca*, or, literally translated, the brown woolly-breasted beetle. The pupa is white."

THE GOLDSMITH BEETLE, *Cotalpa lanigera*, Linn.—Feeding on the roots as grub; very similar to that of the June beetle.

"We also have in the Eastern States an insect allied to the preceding, and with much the same habits, both in the adult and preparatory states. It is the *Cotalpa lanigera*. It is nearly an inch in length, bright yellow above, with a golden metallic luster on the head and thorax, while the under side of the body is copper-colored, and densely covered with white hairs.

"Dr. Harris says that it is very common in this State, remarking that it begins to appear in Massachusetts about the middle of May, and continues generally till the 20th of June. 'In the morning and evening twilight they come forth from their retreats, and fly about with a humming and rustling sound among the branches of trees, the tender leaves of which they devour. Pear-trees are particularly subject to their attacks, but the elm, hickory, poplar, oak, and probably also other kinds of trees, are frequented and injured by them.' Dr. Lockwood has found it on the white poplar of Europe, the sweet gum, and has seen it eating the Lawton blackberry. He adds that the larvæ of these insects are not known; probably they live in the ground upon the roots of plants.

"It has remained for the Rev. Dr. S. Lockwood to discover that the grub or larva of this pretty beetle in New Jersey devastates strawberry-beds, the larva feeding upon the roots, in the same manner as the May

beetle. His account was first published in the American Naturalist (vol. ii, pp. 186, 441). He says that in the month of May in the ordinary culture of his garden the spade has turned up this beetle generally in company with the May beetle. He found that some of the beetles, as in the case of the May beetle, assume the adult beetle state in October and remain under-ground for seven months before appearing in the spring.

"*Larva.*—The larvæ he describes as 'whitish grubs, about one inch and three-quarters long and over half an inch thick, with a yellowish-brown scale on the part corresponding to the thorax.' I may add that it so nearly resembles the young of the May beetle that it requires a close examination to tell them apart. The proportions of the two are much the same; if anything the *Cotalpa* is slightly shorter and thicker, and its body is covered with short, stiff hair, especially at the end, while in the May beetle the hairs are much finer, sparse, and the skin is consequently shiny. They also differ in the head, being fuller, more rounded in *Cotalpa*, the clypeus shorter and very convex, while in the May beetle it is flattened. The upper lip (labrum) is in *Cotalpa* longer, more rounded in front and narrower at the base, and full convex on the surface, while in the young May beetle it is flat. The antennæ are longer and larger in the goldsmith beetle, the second joint a little over half as long as the third, while in the May beetle grub it is nearly three-quarters as long; the third joint is much longer than in the latter grub, while the fourth and fifth are of the same relative length as in the May beetle, but much thicker. The jaws (mandibles) are much alike in both, but not quite so acute in the *Cotalpa* as in the other, nor are the inner teeth so prominent. The maxilla is much longer and with stouter spines, and the palpi are longer and slenderer in the grub of *Cotalpa* than in the other, though the joints have the same relative proportion in each; the basal joint is nearly twice as long as in the May beetle. The under lip (labium) is throughout much longer, and the palpi, though two-jointed in each, are much longer and slenderer in the grub of *Cotalpa* than in that of the May beetle. The feet are much larger and more hairy in the *Cotalpa*. Both larvæ are about an inch and a half long, and a third (.35) of an inch thick at the widest part.

"As regards the number of years in the life of this insect, Dr. Lockwood remarks that 'when collecting the larvæ in May, I often observed in the same places grubs of the *Cotalpa* of at least four distinct ages, each representing a year in the life of the insect, judging from Renny's figures of the larvæ of the English cockchafer, or dor beetle (*Melolontha vulgaris*). But the cockchafer becomes an imago in January or February, and comes forth into active life in May, just four years from the deposit of the egg. Supposing our *Cotalpa* to take on the imago form in autumn, and to spend its life from that time to the next May in the ground, it would be five years old when it makes its *début* as an arboreal insect.' It is possible that Dr. Lockwood may be in error regarding the age of this beetle, as M. T. Reiset says in France this insect is three years in arriving at its perfect beetle state. The following remarks on the habits of the European chafer may aid observers in this country in studying the habits of our native species. M. Meiset says (see 'Cosmos' as translated in the American Naturalist, vol ii, p. 209) 'that this beetle in the spring of 1865 defoliated the oaks and other trees, while immense numbers of their larvæ in the succeeding year, 1866, devoured to a fearful extent the roots of garden-vegetables, etc., at a loss to the department of the Lower Seine of over five millions of dollars. This insect is three years in arriving at its perfect beetle state. The larvæ, hatched from eggs laid by the beetles which appeared in such numbers in 1865, passed a second winter, that of 1867, at a mean depth in the soil of forty one-hundredths of a meter, or nearly a foot and a half. The thermometer placed in the ground (which was covered with snow) at this mean depth, never rose to thirty-two degrees F. as *minimum*. Thus the larvæ survived after being perfectly frozen (probably most subterranean larvæ are thus frozen, and thaw out in the spring at the approach of warm weather). In June, 1867, the grubs

having become full-fed, made their way upward to a mean distance of about 13 inches below the surface, where, in less than two months, they all changed to the pupa state, and in October and November the perfect beetle appeared. The beetles, however, hibernate, remaining below the surface for a period of five or six months and appearing in April and May. The immature larvæ, warned by the approaching cold, began to migrate deep down in the soil in October, when the temperature of the earth was ten degrees above zero. As soon as the snow melted they gradually rose toward the surface.'

"As regards the time and mode of laying the eggs, we quote from Dr. Lockwood as follows: 'On the evening of the 13th June last we caught in the drug-store, Keyport, whither they were attracted by the profusion of light, four *Cotalpas*, representing both sexes. These were taken home and well cared for. On the 16th a pair coupled. A jar of earth was at once provided, and the beetles placed on top of the dirt. In the evening the female burrowed and disappeared. Near midnight she had not returned to the surface; next morning she had re-appeared. The earth was then very carefully taken from the jar, and, as removed, was inspected with a glass of wide field but low power. Fourteen eggs were found, not laid (as we expected) in one spot or group, but singly and at different depths. I was surprised at their great size. Laid lengthwise, end touching end, two eggs measured very nearly three-sixteenths of an inch. They were like white wax, semi-translucent; in form, long-ovoid and perfectly symmetrical. On the 13th of July one had hatched; the grub was well formed and very lively. Its dimensions were about five-sixteenths of an inch in length and about three-thirtieths of an inch in thickness. It was a dull white, the head-plate precisely that dull yellow seen in the adult grub, the legs the same color, and the extremity of the abdomen lead-color, the skin being transparent. For food, a sod of white clover (*Trifolium repens*) was given them, roots downward, knowing that the young larvæ would come upward to eat. They were then left undisturbed until August 19, when the sod was removed, and it was found that the grubs had eaten into it, thus making little oval chambers, which were enlarged as the eating went on. They were carefully picked out and a fresh sod of grass and clover supplied. They had now grown five-eighths of an inch in length, preserving the same colors.

"It is quite possible that a few of the eggs escaped me in the search. I am of opinion, however, that from fifteen to twenty is the average number laid by one beetle. In short, the insect lays her eggs in the night, probably not more than twenty. The hatching of these required in the present instance twenty-seven days. It must be remembered that a large portion of this time was remarkably cold and wet. It is almost certain that with favorable thermal conditions this might be lessened fully seven days.

"Regarding its ravages in strawberry-beds, I cannot do better than quote from Dr. Lockwood's excellent account in the American Naturalist: 'When on a visit in September last to the farm of a celebrated strawberry-grower in Monmouth County, New Jersey, my attention was directed to certain large patches badly thinned out by, as the phrase went, "the worm." The plants were dead on the surface and easily pulled up, the roots being eaten off below. It was observable that the fields which presented the worst appearance were all of the same kind of plant—that known as Wilson's Albany Seedling. Besides this there were nine other varieties under culture, Barnes' Mammoth, Schenck's Excelsior, the Agriculturist, Triomphe de Gand, Cutter's Seedling, the

Jucunda, Pineapple, Early Scarlet, and Brooklyn Scarlet. While the Wilson stood second to none of these as a prolific fruit-bearer, yet it fell behind them in vigorous plant-growth. Hence, while every kind was more or less affected, the other varieties seemed saved by their own growth and energy from a destruction so thorough as was that of the Wilson. These patches were all planted in the spring and all received the same treatment, the ground being kept open and free from weeds. The amount of the spring-planting was seven and a half acres. Of the Wilsons there were three different patches in places quite separated from each other, and on not less than five different kinds of soil. These patches were among and contiguous to those of the other varieties. While all suffered more or less, the chief injury befell the Wilsons, of which not less than two acres were irretrievably ruined. An examination turned up the depredator, who was none other than the larva of the goldsmith beetle, now engaged in the first one of its allotted three-summer campaigns of mischief. These grubs were from the eggs deposited in June in the well-tilled and clean soil, which, I have said elsewhere, I thought the *Cotalpa* preferred to meadow or grass lands. Compared with others, the larva of this beetle is sluggish and easily captured. The black grub of the spring, which is such a pest, attacking almost indiscriminately the early tender plants, inflicts its injuries chiefly in the night, the exception being that of dull and cloudy days. The night's mischief done, it descends into concealment at early dawn. Knowing this, the wise farmer is in search of it at an early hour, ere the warmth of the sun gives it warning to retreat. But the goldsmith grub can be taken at any hour of the day simply by scratching away the earth from around the roots of those plants whose dark, shriveled leaves tell of the enemy's presence. It is my belief that this devastation might have been spared by an outlay of from $20 to $30 for labor, much of which, under proper direction, could have been done by children. Therein would have been saved a strawberry-crop for the ensuing summer, worth scarcely less than $2,500, for from this same farm the crop of a single acre has been sold for $1,500. Then, however valuable such labors are in the immediate results, that is but a fraction of their worth as respects the future. These *Cotalpa* grubs, with all their mischief, had not more than a third of their ultimate size; hence their real ravenousness is yet to come. Besides, what a prospect of increase of numbers, should even a moderate share of them reach maturity! Why should not our farmers seek to know something about their insect-enemies, and, when practicable, put forth some energy to meet such?"

THE STRAWBERRY CROWN-BORER, *Analcis fragariæ* Riley.—Boring from the crown of the plant down into and killing it; a small, soft, fleshy grub, transforming to a weevil.

From the middle of June until the middle of July in Southern Illinois, the grub hatches from an egg, supposed to be deposited by the parent weevil in the crown of the plant, and bores downward into the pith, where it remains until fully grown, "working in the thick, bulbous root, and often eating through the more woody portions; so that when frost sets in, the plant easily breaks off and is heaved out of the ground."—(Riley.) A remedy is difficult to apply, but infested plants should be burned.

FIG. 66.—Strawberry Crown-Borer and Beetle. (After Riley.)

INSECTS INJURING SHADE AND FOREST TREES.

So important to the Western Territories is the preservation and cultivation of forest, as well as shade and ornamental, trees, that a slight sketch of what is known of the insects found in Colorado to be injurious to them will be of some importance until more definite information is obtained. On Plate LXX, I have given outline figures of a number of insects either found living in forest-trees in Colorado, or, from the habits of their allies in the Eastern States, supposed to be injurious.

INJURING CONIFEROUS TREES.

THE SPRUCE-TIMBER BEETLE, *Dryocœtes affaber*, Mannh. (Plate LXX, Figs. 1–3.)

This beetle occurred (July 7) in abundance in all stages in a growth of *Abies menziesii*,* the common spruce of the Rocky Mountains, at Kelso's Cabin, 11,200 feet elevation, on the road to Gray's Peak. It bores into the back and near the sap-wood in all directions, its burrows resembling those of *Tornicus pini*, with which it is associated, being irregular, but much smaller.

The larva (Plate LXX, Fig. 1) is of the usual form of those of the family, being cylindrical and of the same thickness throughout, with the end of the body full and suddenly rounded; segments convex, especially the thoracic ones, and slightly hairy. Head two-thirds as wide as the body, rounded, honey-yellow. Length, 0.15 inch.

The pupa is much like that of *T. pini*, with two anal soft, sharp tubercles. As my specimens are farther advanced than those of *T. pini*, the wings being free from the body, and the abdomen longer, it is impossible for me to draw up a good description. In one example, the pupa had retained the larval head, but it was split behind so as not to interfere probably with the development of the adult beetle.

The beetle (Plate LXX, Fig. 3) differs from *T. pini* in its much smaller and slightly slenderer body. The head and prothorax are two-thirds as long as the rest of the body. The abdomen is not scooped out at the end as in *T. pini*, but truncated, moderately rounded, and the end of the abdomen reaches to the end of the wing-covers, which are square at the end instead of excavated as in *T. pini*. Color reddish-brown, much as in *T. pini*. The body is covered with fine, stiff, straight hairs. Length, 0.14 inch.

THE PINE-TIMBER BEETLE, *Tornicus pini* Say. Pupa and beetle. (Plate LXX, Figs. 4, 5.)

This timber-beetle was common, boring irregularly into the inner bark of *Abies menziesii*. The burrows are like those made by the same insect in the white pines from Maine to North Carolina. On the Atlantic coast the more regular burrows radiate from a common center. Those observed on Gray's Peak were 0.08 inch in diameter.

In the pupa the body ends in two long, pointed, horn-like appendages arising from each side beneath. The ends of the hind tarsi extend to the terminal third of the wings. The antennæ are clavate, not extend-

*This tree was kindly identified for me by Mr. Sereno Watson, from specimens of the leaves and cones sent him for identification.

ing beyond the coxæ of the first legs. It is larger, more bulky than the adult. Length, 0.22 inch.

The beetle (Plate LXX, Fig. 4) is cylindrical, with the head and prothorax together three-fourths as long as the rest of the body; end of the abdomen suddenly truncated, slanting, forming a scoop, the declivity smooth, concave, and bounded by high walls, which are four-toothed on each side, the third from the top the largest. On each wing-cover are eight lines of fine, raised tubercles; prothorax with concentric rows of fine tubercles, but smooth on the posterior third. Seen from beneath, the wing-covers project well beyond the end of the abdomen. Color, pale tan-brown, a little paler on the thorax than on the wing-covers. Body covered with stiff, dense hairs. Length, 0.20 inch.

THE STOUT PINE-BORER, *Dendroctonus obesus* Mannh. (Plate LXX, Fig. 16.)

This beetle is not uncommon in Colorado. I met with it at Blackhawk and at Manitou. It probably bores in the pines and spruces of the mountains. It is short and stout, reddish-brown, the head and prothorax smooth and shining, though finely punctured, while the wing-covers are coarsely punctured and dull-colored, being a little darker than the rest of the body. Length, 0.35 inch.

It scarcely differs from the *Dendroctonus terebraus* of the Eastern States, which I have found in all stages in great abundance under the bark of the white pine, associated with *Pissodes strobi.* It mines the inner surface of the bark, slightly grooving the sap-wood, and pupates in April, appearing as a beetle in great numbers on warm days early in May. On a cursory examination I am unable to see any difference between the eastern species and *D. obesus*, except that the latter is slightly larger.

INJURING DECIDUOUS SHADE AND ORNAMENTAL TREES.

The following beetles are common in Colorado and the Rocky Mountains, and in most cases will probably be found ere many years to be injurious to the trees in towns and on farms. Knowing as yet nothing of their habits I have thought it well to select a few of the more common species and present such figures and brief descriptions of them as may prove useful to western gardeners and farmers hereafter. I will not attempt to coin English names for them. The localities are given in the List of Coleoptera collected by me in Colorado, at the end of this report.

PRIONUS EMARGINATUS Say. (Plate LXX, Fig. 6.)

"Body castaneous; head, thorax, and breast covered with long yellowish-ferruginous hair; antennæ fourteen-jointed, glabrous, perfoliate, imbricate; the imbrications emarginate beneath; mandibles black at tip; thorax but slightly margined, one-toothed on the middle of the lateral edge; angles obtusely rounded; elytra somewhat unequal, punctured; feet and venter subglabrous. Length nearly seven-tenths of an inch. Female glabrous; antennæ simple. Length four-fifths of an inch. This species exhibits the general form of *brevicornis*, but the thorax is proportionally much narrowed, and the characters above detailed prove it to be very distinct from that species. The lepaceous processes of the antennæ are so profoundly emarginate beneath as to appear each bilobate. I obtained it on the Arkansas River near the mountains."—(Say.)

CRIOCEPHALUS PRODUCTUS Le Conte. (Plate LXX, Fig. 7.)

Varying from dark brown to black-brown; unspotted, with two high, thin, raised lines or ridges on each wing-cover. It is closely allied to the eastern *C. agrestis*, but is somewhat narrower, and the ridges are much more prominent. Length, 0.80–0.85 inch.

DECTES SPINOSUS (Say). (Plate LXX, Fig. 8.)

"Head deeply indented between the antennæ; labrum piceous; antennæ longer than the body, black, each joint gray at base; thorax cylindrical, immaculate; an acute, slightly-recurved spine near the posterior angles; elytra (wing-covers) with numerous small impressed punctures, at tip truncated; venter with a series of almost concealed black spots on each side. Length more than three-tenths of an inch."—(Say.) "I formed a special genus, *Dectes*, for this insect, but it seems to be scarcely distinct from *Liopus*."—(Le Conte.)

POGONOCHERUS MIXTUS Haldeman. (Plate LXX, Fig. 9.)

"Head sparsely hairy, black, with an indistinct yellowish spot before the eyes; frontal line impressed; antennæ testaceous, with the tip of the articulations blackish; scutel black; elytra hispid; base, middle, and apex brown; extreme tip and an oblique band before the middle running forward and outward, yellowish, with a few brown dots; extreme base testaceous; feet brown, varied with testaceous; 2½ lines long. Pennsylvania."—(Haldeman.)

MECAS PERGRATA SAY. (Plate LXX, Fig. 10.)

"Body black, covered with short, prostrate hair, which partially conceals the punctures; antennæ nearly as long as the body, annulate with cinereous and black; thorax slightly dilated in the middle; a transverse, arcuated series of four glabrous spots, and a longitudinal, abbreviated, glabrous line behind the middle; scutel whitish; elytra with a narrow white margin and suture; tip entire; thighs dull rufous. Length about nine-twentieths of an inch. Upon the middle of each elytron is a very indistinct rufous line, which is only visible upon close inspection, and is very probably often wanting; a similar spot is upon the anterior portion of the thorax; the white appearance of the margin of the elytra is occasioned by the more dense disposition of the hairs on that part. We captured but a single specimen on the Platte River (Nebraska) near the mountains."—(Say.)

CHRYSOBOTHRIS TRINERVIA (Kirby). (Plate LXX, Fig. 11.)

A rather small, short, broad species, dull blackish, with faint, metallic reflections. Surface of the body, especially the wing-covers, with irregular ridges, the inner one parallel to the inner edge of the wing-cover; wing-covers with smooth elevated areas, between which the surface is minutely pitted with dense golden punctures. Body clothed beneath with short, coarse hairs. Length, 0.45 inch.

BUPRESTIS RUSTICORUM Kirby. (Plate LXX, Fig. 12.)

Body brown, with an olive-green tint. Head and thorax punctured. Each wing-cover with five ridges, four of them well-marked and smooth,

the interspaces with scattered punctures. On the head between the eyes are five yellow spots; two simple dots, two long spots on the orbits, sending two projections ontward, and a line in front sending three projections upward. Two unequal yellow spots under the eyes. Labrum and labium yellow. Five orange-yellow spots on each side of the end of the abdomen beneath. Length, 0.84 inch.

DICERCA PROLONGATA Le Conte. (Plate LXX, Fig. 13.)

"Coppery gray, often pruinose; width of thorax twice its length, sides well rounded in front, behind somewhat sinuous, punctate, furrowed, each side with an oblique, deeply-impressed line; wing-covers with deeply-impressed lines; apex rounded, the wing-covers scarcely divaricate. Length, 0.77–0.85 inch."—(Le Conte.)

MELANOPHILA DRUMMONDI Kirby. (Plate LXX, Fig. 14.)

Body densely punctured, shagreened; shining, reflecting metallic colors, especially on the prothorax, with three bright yellow spots on the posterior two-thirds of each wing-cover, the anterior spot being the larger. Length, 0.40 inch.

THE GIRDLER, *Oncideres cingulatus* Say. (Fig. 67.)

Although this beetle is not known to inhabit Colorado or the Rocky Mountains, I have thought it well to introduce the following figure received from Prof. I. S. Haldeman, of Chickies, Pa., as illustrating its mode of cutting off hickory branches. Professor Haldeman's account is given at length in the "Guide to the Study of Insects", p. 498.

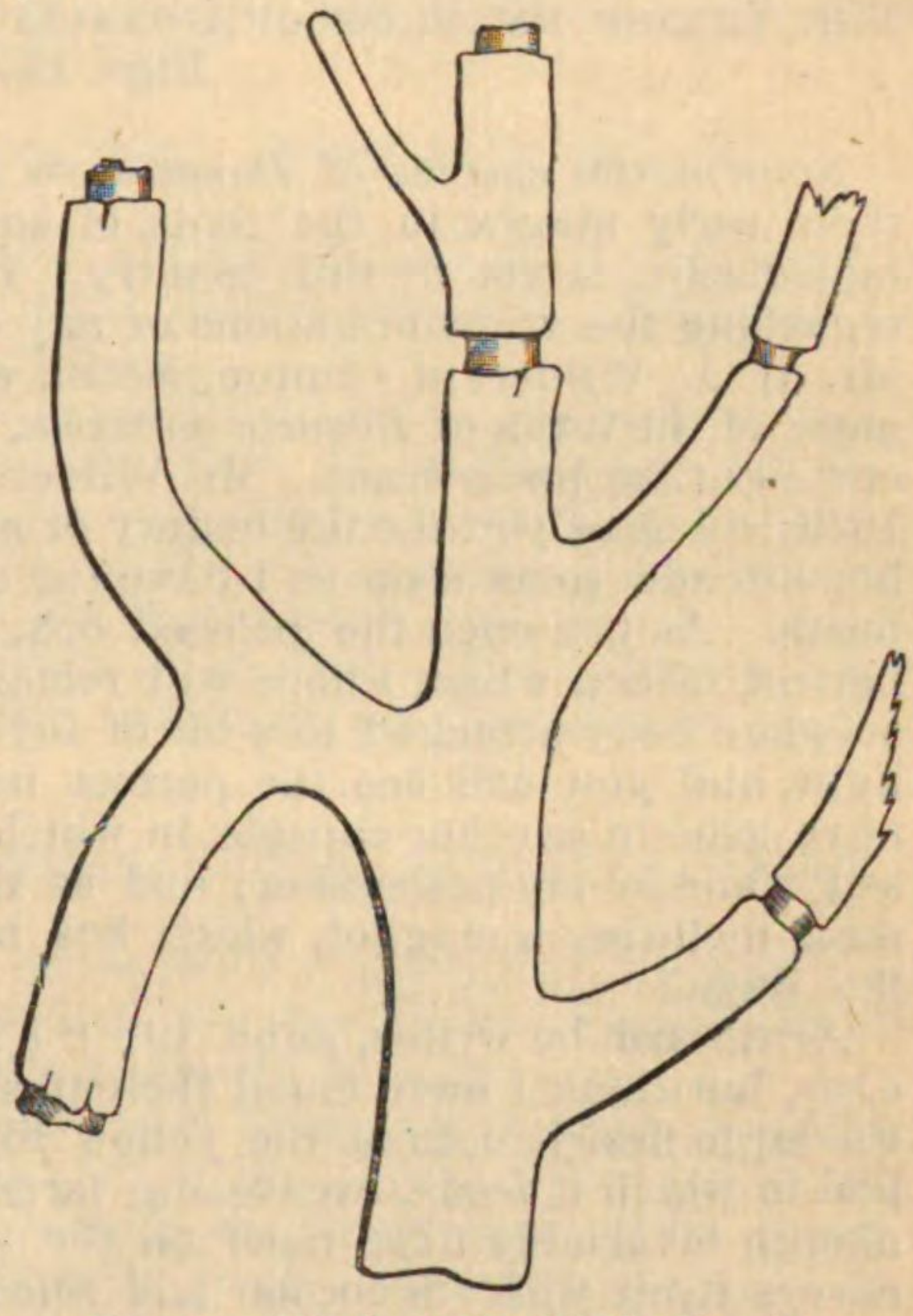


FIG. 67.—Work of the Girdler Beetle.

INSECTS NOT SPECIALLY INJURIOUS.

THE TRANSFORMATIONS OF PLEOTOMUS PALLENS Le Conte.

It is not improbable that this insect in its early stage as a larva is beneficial to vegetation, since so far as known the young of our fire-flies devour worms, other larva, and snails, but the individuals of this species are so rare, that they probably exert but a slight influence for good or evil, agriculturally speaking. I have received three specimens of this larva from Texas through Mr. G. W. Belfrage, on whose authority solely the above determination is given. For a specimen of the male, and of the exceedingly rare female, I am indebted to the kindness of G. D. Smith, esq., of Boston, who loaned them for the purpose of being drawn.

The larva is unsually long and narrow, and much flattened. The pro-

thoracic segment is nearly as wide as long, much rounded in front; this and each following segment reddish, with three yellowish lines, viz, a faint, straight, median one, and two curved lateral ones; these lines on the abdominal segments more diffuse and indistinct. The mandibles are long, sickle-shaped, acute, much curved. The maxillary and labial palpi project considerably beyond the curve of the mandibles. Maxillary palpi long and stout, three-jointed; the two terminal joints long and slender, and of equal length; the terminal third joint projects its entire length beyond the end of the labial palpi. The latter are three-jointed, the third joint very minute. The terminal segment of the body is small, one-half as wide and one-half as long as the preceding joint. The feet are well developed, ending in a single claw. There are nine pairs of spiracles. Length, 0.50 inch.

THE TRANSFORMATIONS OF DONACIA PROXIMA Kirby. (Plate LXX, Figs. 17–19.)

None of the species of *Donacia*, so interesting from their living in their early stages in the roots of aquatic plants, have been studied biologically as yet in this country. For the first information we have regarding the transformations of any of our species we are indebted to Mr. W. L. Wilder, of Clinton, Mass., who kindly sent me living specimens of the larva of *Donacia proxima*, found June 23 in the roots of the cow-lily (*Nuphar advena*). Mr. Wilder writes me under date of May 23, 1876: "I send you the life-history of an insect, except the egg, which I hope to add to as soon as I have the mud in which the larva first appears. As you open the inclosed box, if all is right, you will find the perfect insect, which I hope will remain alive; 2d, you will find a capsule-like body attached to a bit of lily-root; examine it by transmitted light, and you will see the perfect insect ready to emerge. You will next come to another capsule, in which a white maggot has inclosed itself while in my possession; and at the bottom of the box is a ball of mud inclosing a maggot, which has hatched out in the mud within a few days."

Afterward he writes, June 19; "I have not been able to find the eggs, but think I have found their place of deposit in small cavities in the large fleshy roots of the yellow lily, into which the larva burrows, and in which it feeds, excavating large chambers after it emerges, and almost invariably fixes itself on the tender rootlets beneath, where it covers itself with its cocoon and remains until mature. I have found the larvæ in the root and with no outlet but the small puncture where the eggs were deposited. I could have sent you hundreds of the pupæ just ready to emerge."

Afterward the cocoons containing the beetles were found October 24, 1876, attached to the roots of the cow-lily (*Nuphar advena*), in a pond at Salem, Mass., and presented by Mr. S. B. Buttrick to the museum of the Peabody Academy of Science, so that we probably have nearly the entire history of the insect. The females probably winter over in the dense, tough, parchment-like brown oval cocoons (Plate LXX, Fig. 17, natural size), and in the spring lay their eggs in such a position that the larvæ on hatching bore into the roots of the lily; the larvæ, becoming fully developed by the end of June, transform into chrysalides, previously spinning a cocoon much like that of the saw-flies, and assuming the beetle condition in the autumn.

The body of the larva (Plate LXX, Fig. 18, enlarged, seen from beneath) is white, thick, fleshy, cylindrical. The head is small, reddish, one-

third as wide as the segment behind it; it is thick, and about as long as broad. The antennæ are short, conical, three-jointed; the maxillary palpi are short, projecting but slightly beyond the ends of the labial palpi; they are three-jointed; the first but slightly shorter than the second; third but half as wide and half as long as second. Labial palpi minute, consisting of but a single joint, while the labium itself is large and fleshy. Three pairs of well-developed legs, which are two-jointed, ending in a single stout claw. The end of the body is suddenly somewhat flattened and bent over onto the ventral side, and is armed above with two parallel, flat, blade-like chitinous appendages, a little curved and appressed to, though free from, the surface on which they rest, reaching to the tip of the body, and curved slightly backward. The segments of the body are quite convex, the sutures deeply impressed, and the exposed parts of the body are covered with fine hairs. The prothoracic segment is slightly reddish, pale brown posteriorly. Length of the body when curved, 0.56 inch; thickness, 0.20 inch.

DERMESTES MARMORATUS Say. (Plate LXX, Fig. 15.)

This is the common larder-beetle of Colorado and other Western Territories, and is noticed here as likely to be annoying in museums, and as a nuisance in pantries and kitchens.

"Antennæ reddish-brown; thorax indented before the scutel; pectus blackish; postpectus and coxæ with dense white hair; feet blackish; intermediate and posterior thighs with a white band before; spot on the lateral basal margin of the elytra large, angular; venter with dense white hair; anal segment and lateral spots black-brown. Length from three-tenths to nine-twentieths of an inch. This insect is of frequent occurrence is Missouri and Arkansas, and is a large species."—(Say.)

THE CALIFORNIAN LAPPER MOTH, *Gastropacha californica* Pack.

This and the following moth are somewhat annoying insects in California, feeding upon the oak, and at my request Mr. Henry Edwards has furnished me with the following account of them:

"The moth lays its eggs in June, and they must remain unhatched until the following spring. Just when the young shoots of the oaks (*Quercus agrifolia* Nee) begin to appear, the larvæ make their appearance also, spinning thin and irregular webs over the branches of the trees. In these webs they house mostly during the heat of the day, but sally forth in the evening and at night for food. In this way they will soon strip a tree of its leaves, though it is well to say that the oaks do not seem to be permanently affected, as they soon send forth fresh shoots, and toward the time that the caterpillars undergo their change to the chrysalis they are green and gay again. The larvæ retain the shelter of their web until after the third month, when they wander away singly, are found everywhere, becoming sometimes a complete nuisance in gardens and fields. They feed in their more mature stages upon many plants besides the oak, eating with avidity willows, ash, *Æsculus californica*, *Photinia arbutifolia*, *Arbutus menziesii*, as well as apple and pear trees. Toward the end of May they spin their cocoons, seeming to have no choice of locality, but fixing themselves wherever they may chance to be, either on walls, palings, trunks or branches of trees, stems of grapes, or among the leaves of herbaceous plants. The time in the chrysalis state is about eighteen to twenty-one days, so that

the moths emerge and are in the greatest abundance about the middle of June. They come very readily to light, and are a pest to the entomologist in his nocturnal rambles. I regret that I cannot now send you descriptions of the larva and chrysalis. Mr. Stretch has them prepared for his forthcoming book on our *Bombycidæ*, and I am sure he will forward them to you. I will write and ask him to do so. I can send you the perfect insects if they are of value to you."

PHRYGANIDEA CALIFORNICA. (Plate LXX, Fig. 22, male.)

The following account has been furnished by Mr. H. Edwards:

"This insect is also very destructive to our young oaks, the caterpillars, which are perfectly naked and with the head almost monstrous in size, making their appearance about the same time as those of *Gastropacha*. They are restless little creatures, wandering incessantly over the trees, and feeding very rapidly. They spin no cocoon, but hang by the tail, like the larva of *Vanessa*, etc. The change to the chrysalis is undergone in April and May, and the moths appear in about fifteen or sixteen days. There is a second brood of these insects, the imagos of the latter appearing in September and October. Indeed, fresh specimens are now upon the wing, though the second brood is by no means so abundant as the first. I have observed that *Phryganidea* and *Gastropacha* never associate upon the same tree, and I think that the former has always the mastery. This is perhaps owing to some excretion from its body which is unpleasant to the *Gastropacha;* but of course I do not speak with certainty as to this fact. It is, however, sure that they are never found in large quantities on the same tree. I am inclined to think that *Phryganidea* is more destructive to the oaks than the other species, as it feeds solely upon *Quercus*, while the other, as I have said, is not so particular in the choice of its food. I inclose my published description of the egg of *Phryganidea*. I quote Mr. Edwards's description of the egg and larva:

"The egg is spherical, a little flattened above, shining, yellowish-white at exclusion, attached in clusters of about ten or twelve to the upper side of the leaves. The third day the apex of the egg assumes a dull orange hue, afterward changing to a bright reddish-purple and gradually to a duller shade as the young larvæ emerge. The eggs were laid by a female in my possession on July 5. In the young larva the head is very large, almost monstrous, pale olive-brown, with a narrow black line at base; body pale canary-yellow, with four rows of black spots arranged longitudinally in lines.

"The mature form of the larva is noticed in Stretch's '*Zygaenidæ* and *Bombycidæ* of North America,' but I subjoin the description of one of the many varieties to which it is subject, believing that all information with reference to this species (the position of which in classification has not yet been settled by entomologists) will prove to be of value: Yellowish-white, shining, head large, round, stone color, with a black point on each side of the mouth; a median stripe of reddish-brown and a narrow one of the same color on each side. A broad black stripe extends laterally across the second segment at base of the head and another across the thirteenth segment, which also contains a broken black dorsal line. In the middle of the black lateral stripe is a waved whitish line, inclosing a narrow black one. At the base of the abdominal legs is a waved interrupted yellow line, edged narrowly with black; under side yellowish-white, faintly marked with broken brown waved lines; feet pinkish, striped with black; abdominal legs yellowish-white."

Mr. Behrens, of San Francisco, writes me that three generations of the *Phryganidea* appear in a year. "In 1875 it, with the larva of the *Gastropacha californica*, ate our evergreen oaks to broomsticks. You could hear the caterpillars eat and their manure drop, the latter covering everything; it could be swept together by the bushelful. In the wake of both followed ichneumon parasites."

EXPLANATION OF PLATE LXII.

FIG. 1. Rocky Mountain locust.—*a*, *a*, *a*, female in different positions, ovipositing; *b*, egg-pod extracted from the ground, with the end broken open, showing how the eggs are arranged; *c*, a few eggs lying loose on the ground; *d*, *e* show the earth partially removed to illustrate an egg-mass already in place and one being placed; *f* shows where such a mass has been covered up.—After Riley.

FIG. 2. Rocky Mountain locust.—Front and side view of the embryo surrounded by the inner embryonal membrane or amnion. Original: drawn by J. H. Emerton.

FIG. 3. Rocky Mountain locust.—*a*, *a*, newly-hatched larvæ; *b*, full-grown larvæ; *c*, pupa.—After Riley.

FIG. 4. Rocky Mountain locust.—Process of acquiring wings; *a*, pupa with skin just split on the back; *b*, the adult extruding; *c*, the same nearly out; *d*, the same with wings expanded; *e*, the same with all the parts perfect.—After Riley.

FIG. 5. *a*, Rocky Mountain locust; *b*, the common red-legged locust.—After Riley.

FIG. 6. Rocky Mountain locust.—Terminal abdominal ring; *a*, side view; *b*, *c*, hind and top view of the same.—After Riley.

FIG. 7. Red-legged locust.—Lettering and explanations the same as in Fig. 6.—After Riley.

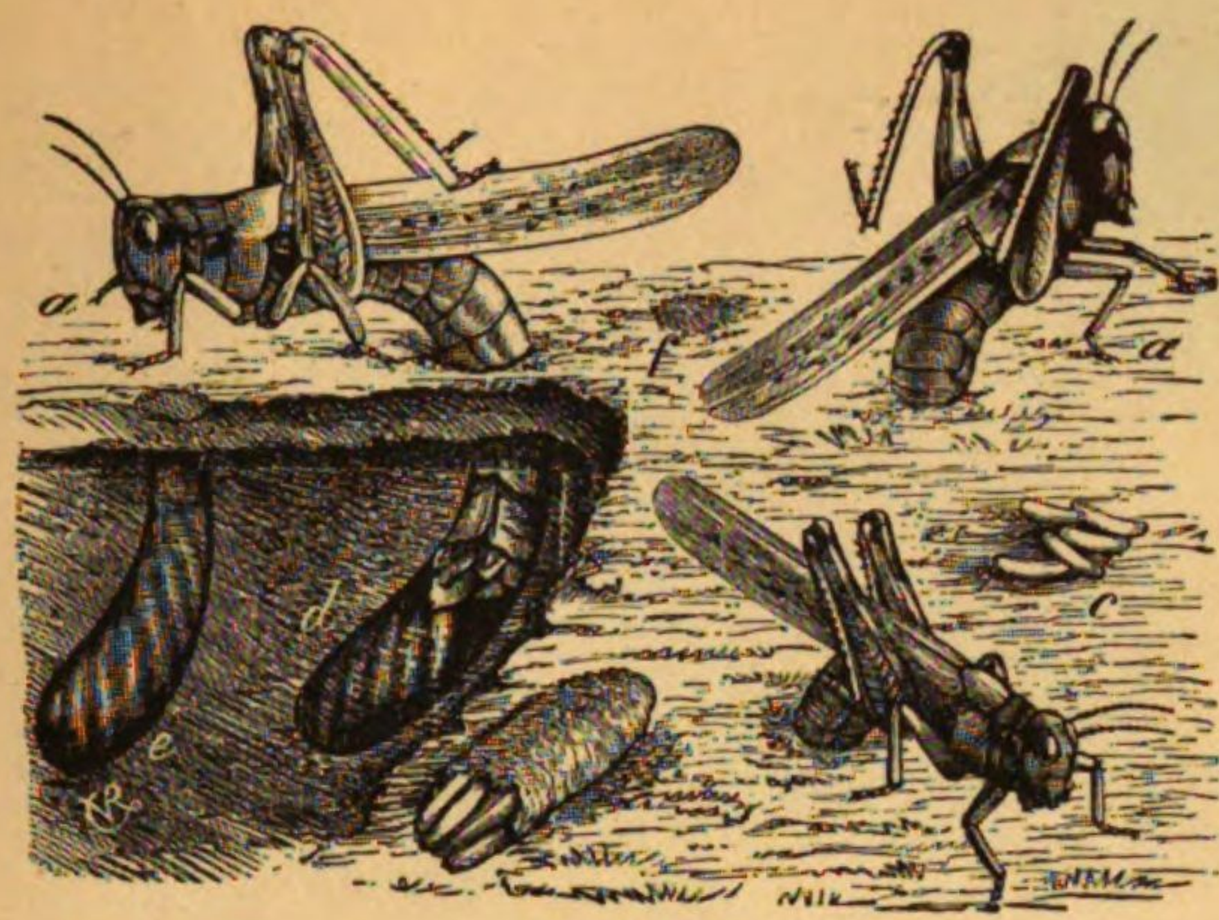
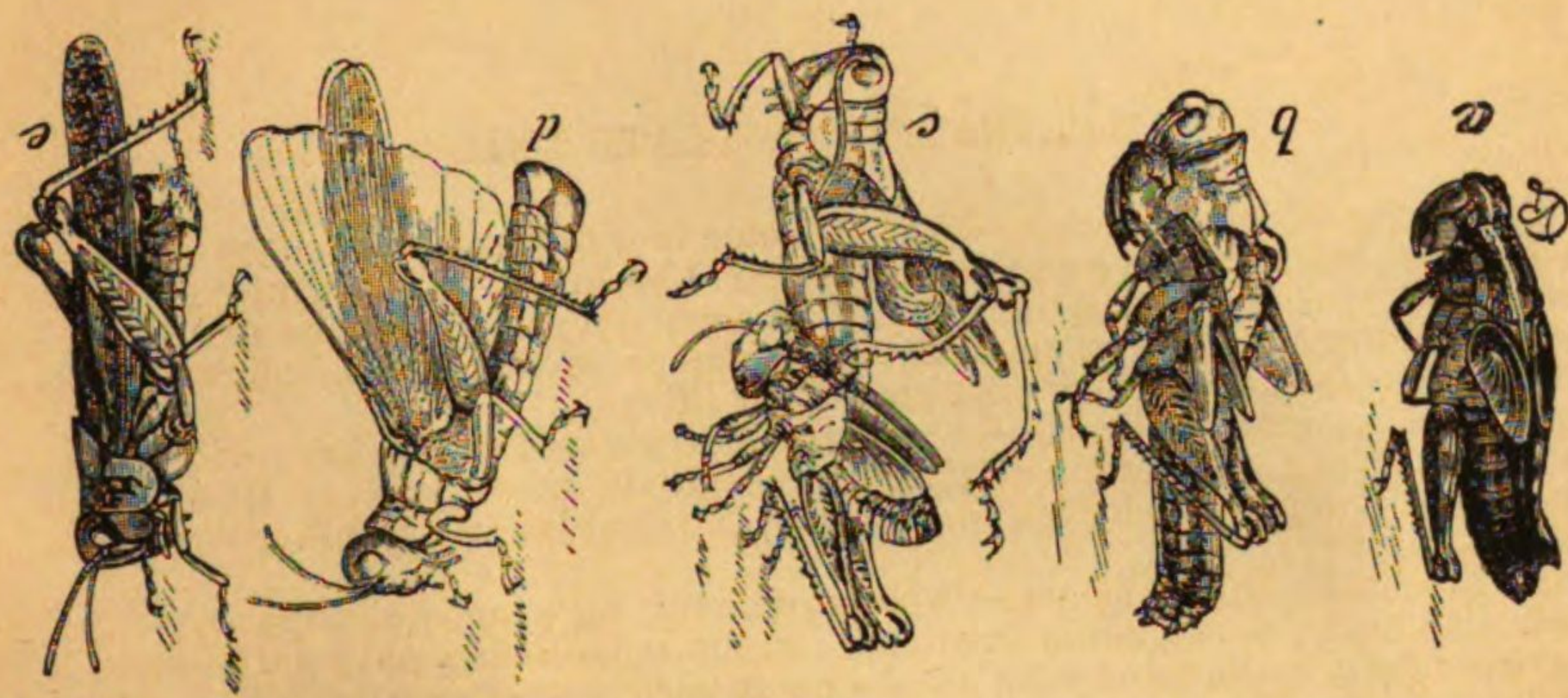


Fig. 1.



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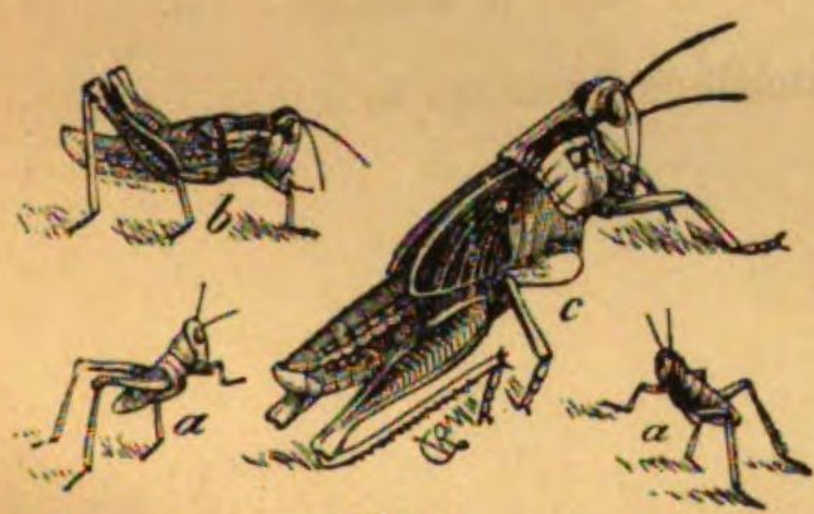
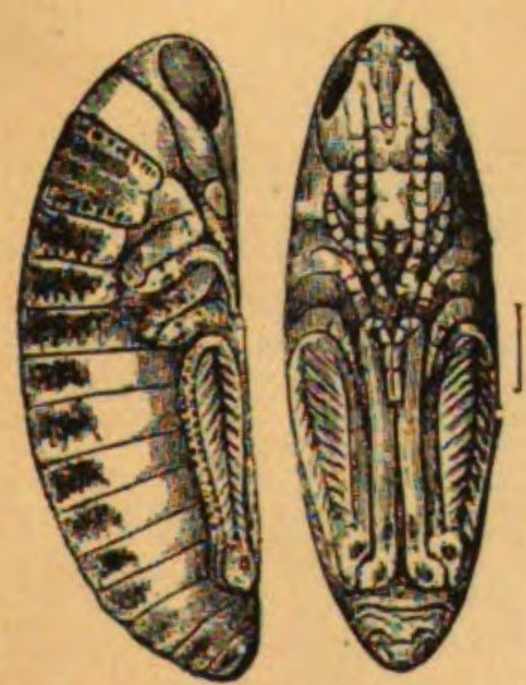


Fig. 3.

Fig. 6.

Fig. 7



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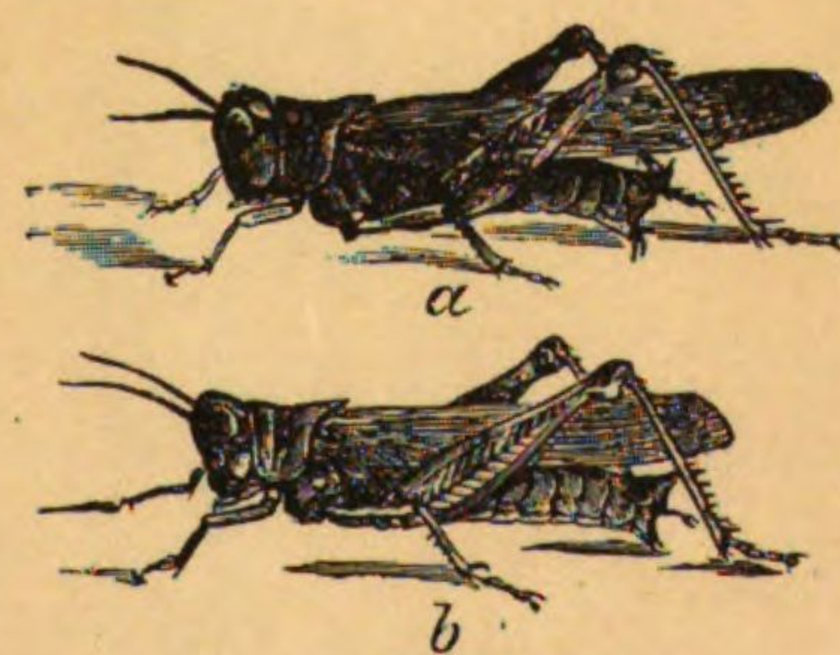
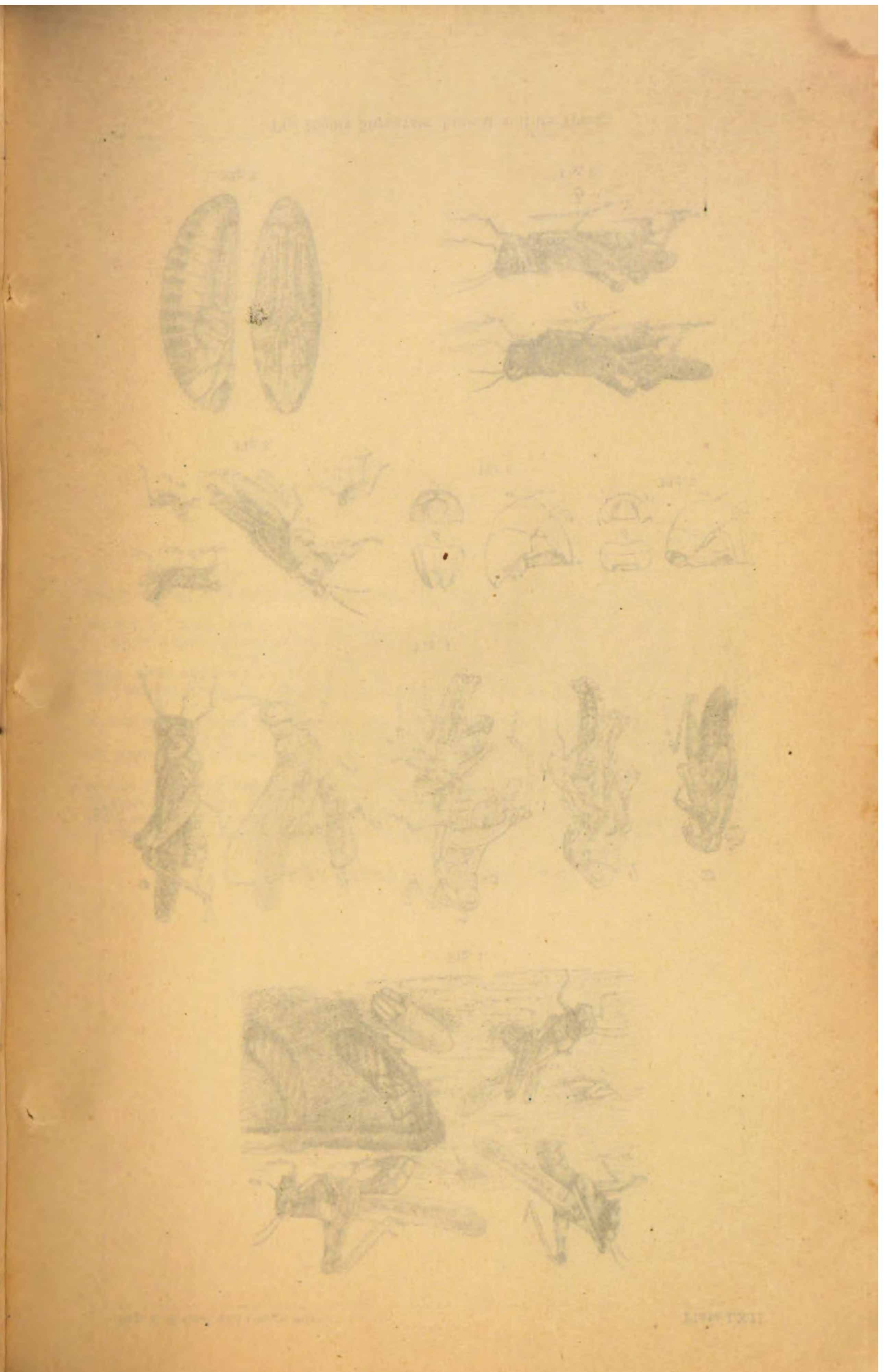


Fig. 5.

The Rocky Mountain Locust and its Young.



EXPLANATION OF PLATE LXIII.

FIG. 1. Larva of *Harpalus*, feeding on eggs of locust; enlarged. (Emerton del.)

FIG. 2. Larva of *Anthomyia radicum*, var. *Calopteni* Riley, feeding on eggs of locust. *a*, larva, enlarged twice; *b*, pupa-case, natural size; *c*, the same magnified twice. The cross-lines represent the length of body and expanse of wing of the fly, which is magnified three times.—(After Curtis.)

FIG. 3. Red-tailed Tachina fly (after Riley). *a*, a larva of Tachina which preys on the European cabbage-butterfly, introduced to illustrate the maggot of Tachina.

FIG. 4. *Trombidium sericeum* Say, natural size and magnified.

FIG. 5. The Red mite, young of a species of *Trombidium* (*Astoma gryllaria* Le Baron); enlarged.

FIG. 6. *Gordius aquaticus*. A, egg; B, egg undergoing segmentation of the yolk; C, embryo (gastrula) with the primitive stomach an infold of the outer germinal layer of cells (ectoderm); D, embryo farther advanced; E, larva, with the three circles of spines retracted within the œsophagus; F, the same stage greatly enlarged to show the internal organs; *c*, middle circle of spines, the head being retracted; *m*, muscular layer (?); *t*, beak or proboscis; *i*, intestine; *z*, *z*, embryonal cells; *f*, excretory tube leading from *g*, the secretory glands; *œ*, œsophagus; *v*, rectum; *n*, anus. G, the second larva, encysted in a fish—(after Villot). H, *Gordius varius*, end of body of male, much enlarged. I, *Gordius aquaticus*, end of body of male, much enlarged. K, *Gordius aquaticus*, natural size. (H, I, K, drawn from nature by J. S. Kingsley.)

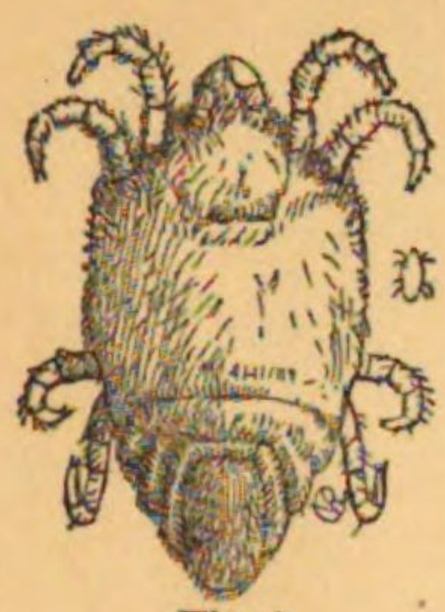


Fig. 4.

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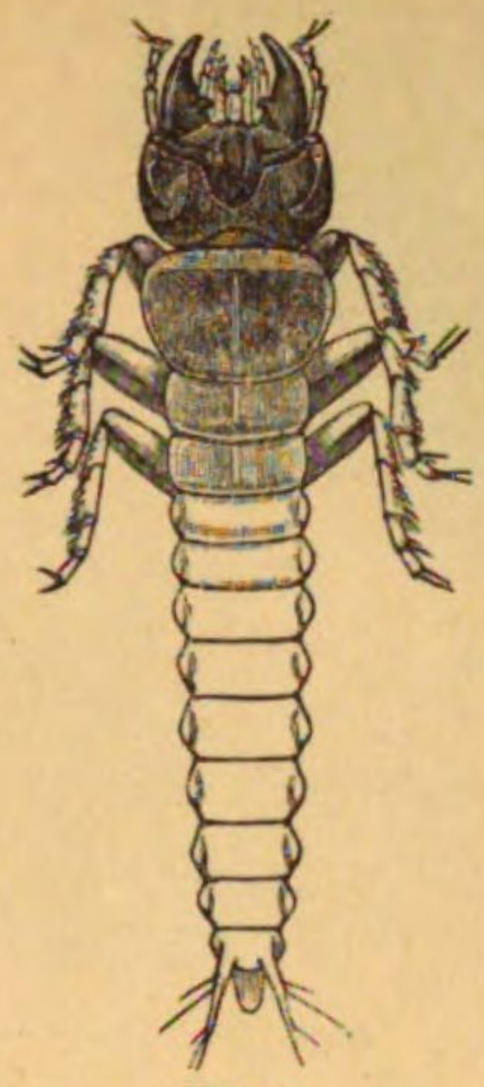

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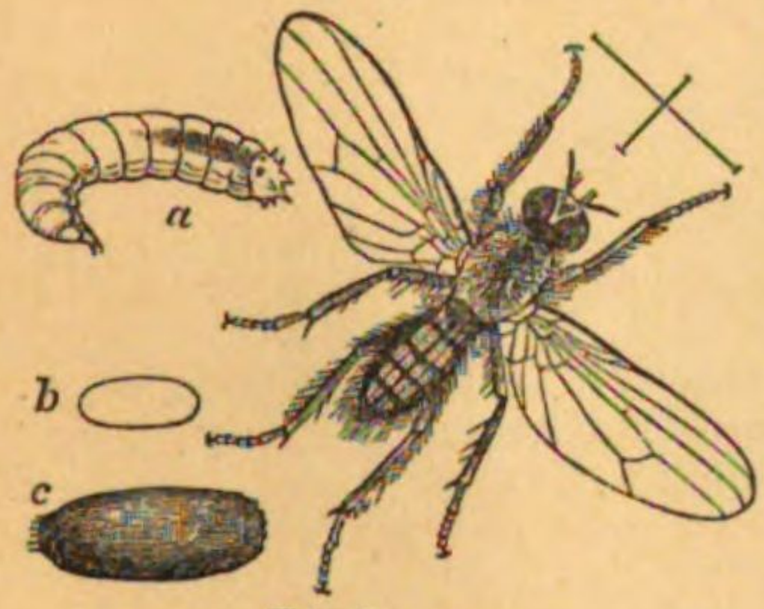

Fig. 2.

Fig. 3.

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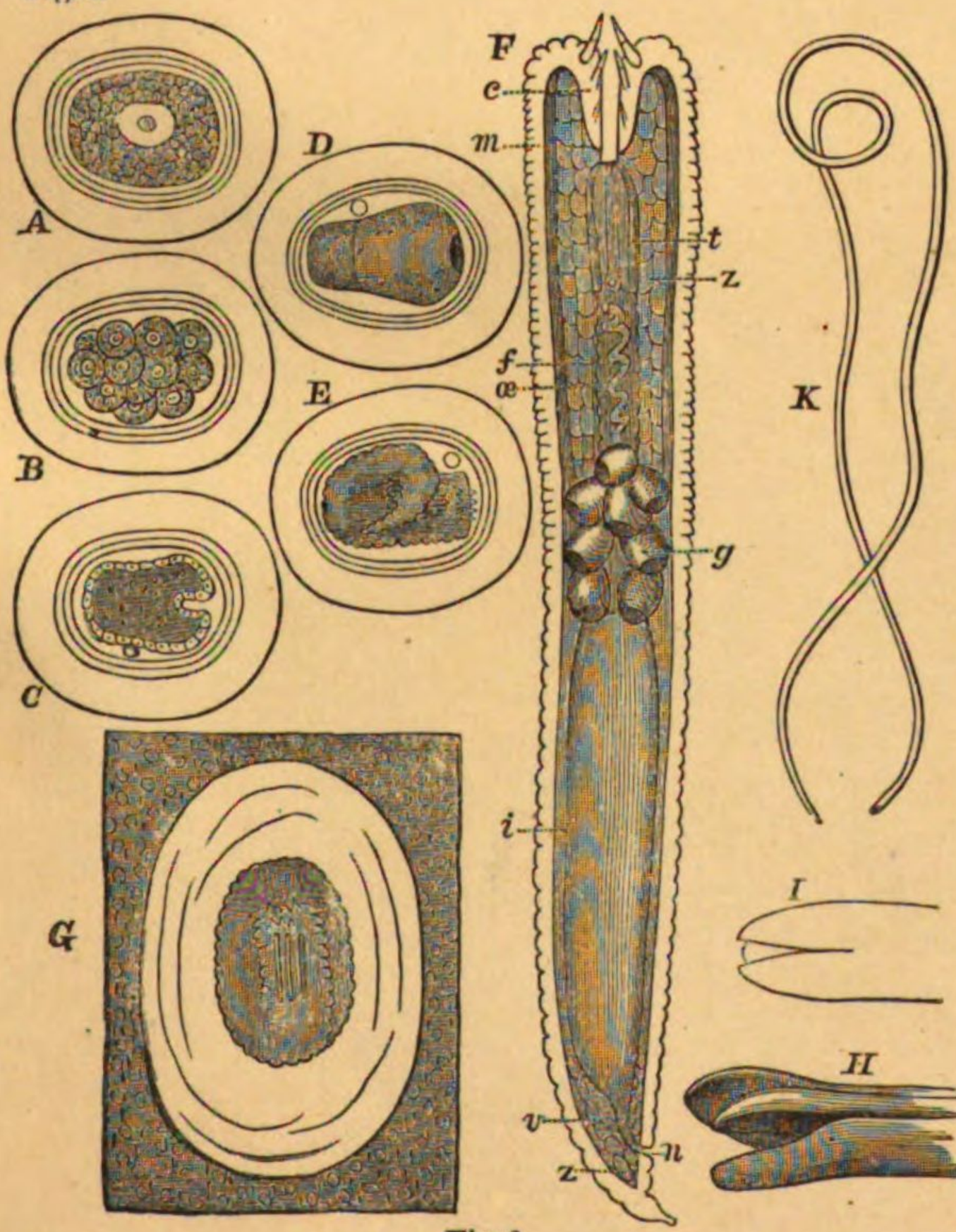


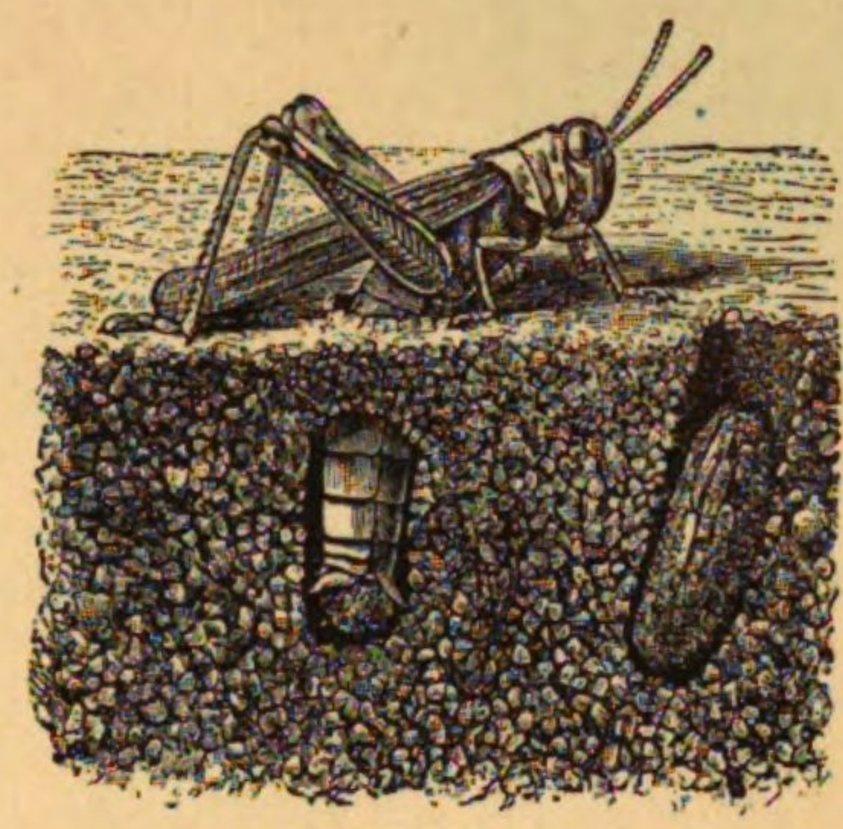
Fig. 6

Parasites and Enemies of the Rocky Mountain Locust.

EXPLANATION OF PLATE LXIV.

FIG. 1. Larva of *Sarcophaga carnaria*, enlarged.
FIG. 2. Pupa-case of the same, enlarged.
FIG. 3. Adult of the same, enlarged. (Figs. 1–3, Emerton del.)
FIG. 4, Red-legged locust, engaged in laying its eggs; to the right, a hole containing an egg-mass, natural size.
FIG. 5. *Œdipoda* (*Camnula*) *pellucida* (*atrox*), Emerton del.
FIG. 6. *Acrydium americanum*, natural size, (after Riley).

Fig. 5.



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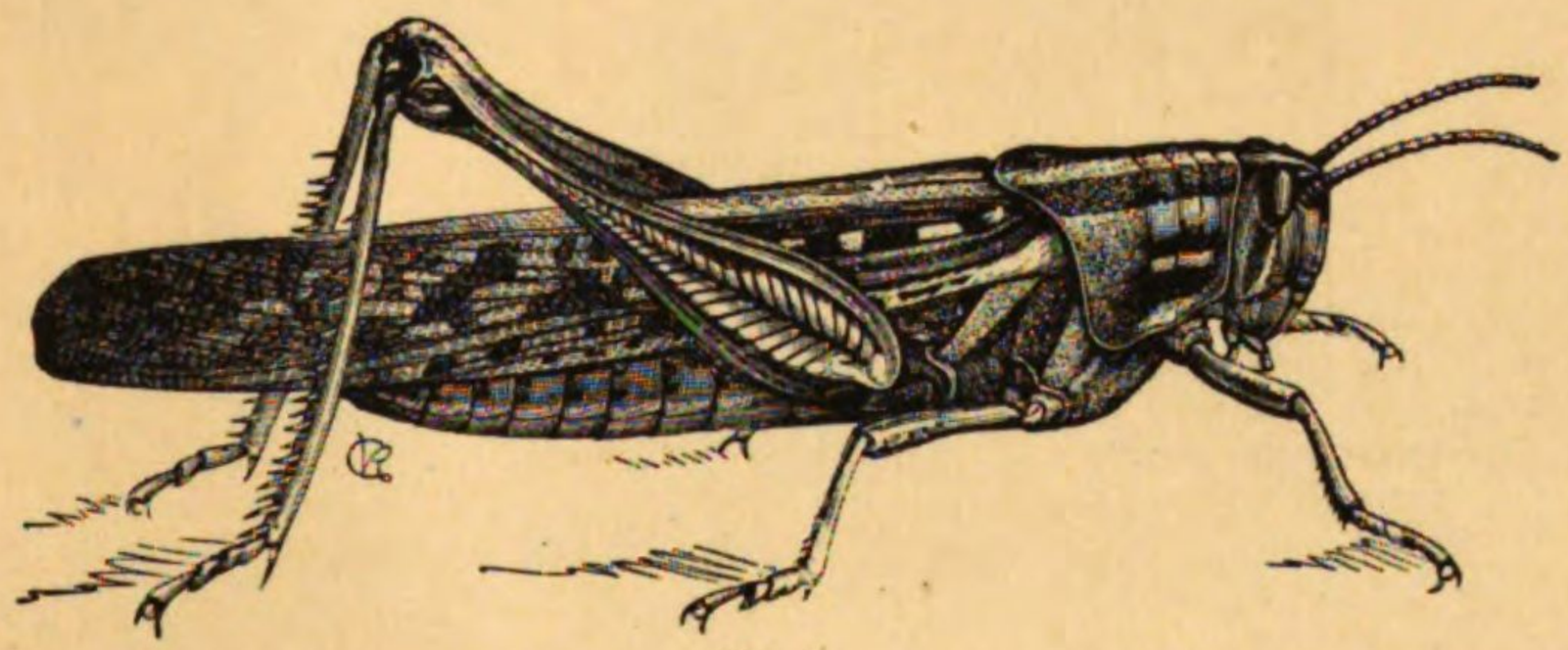
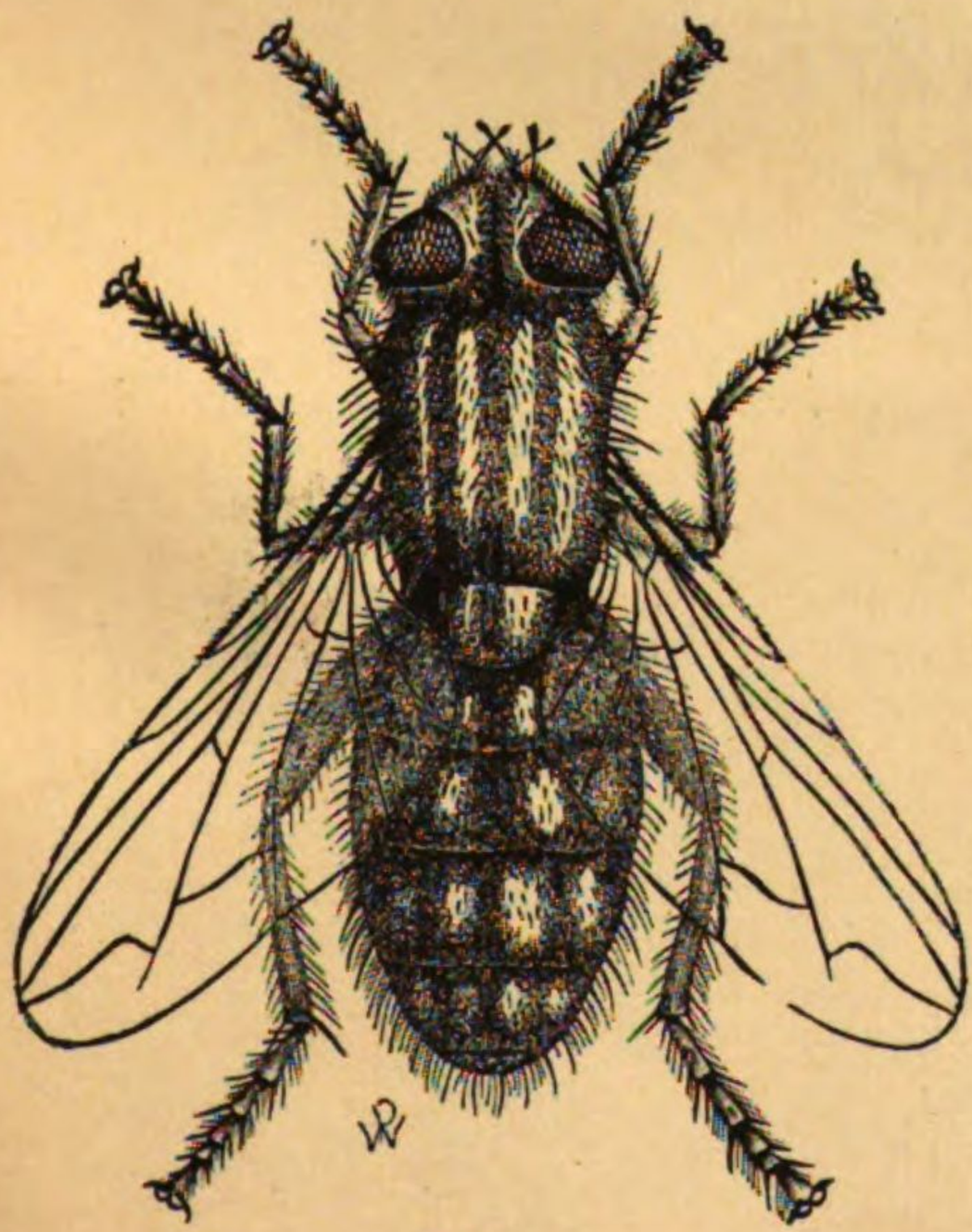


Fig. 6.



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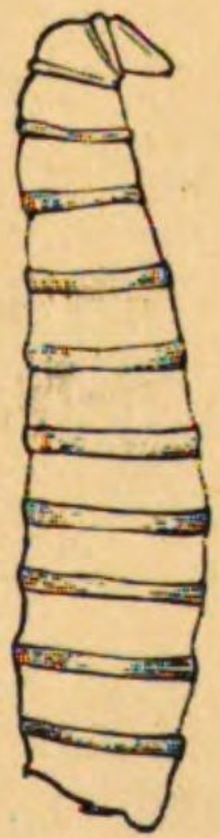

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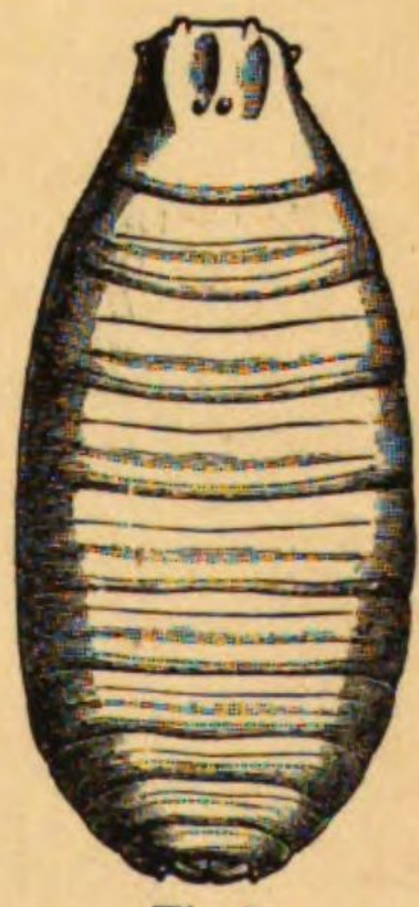
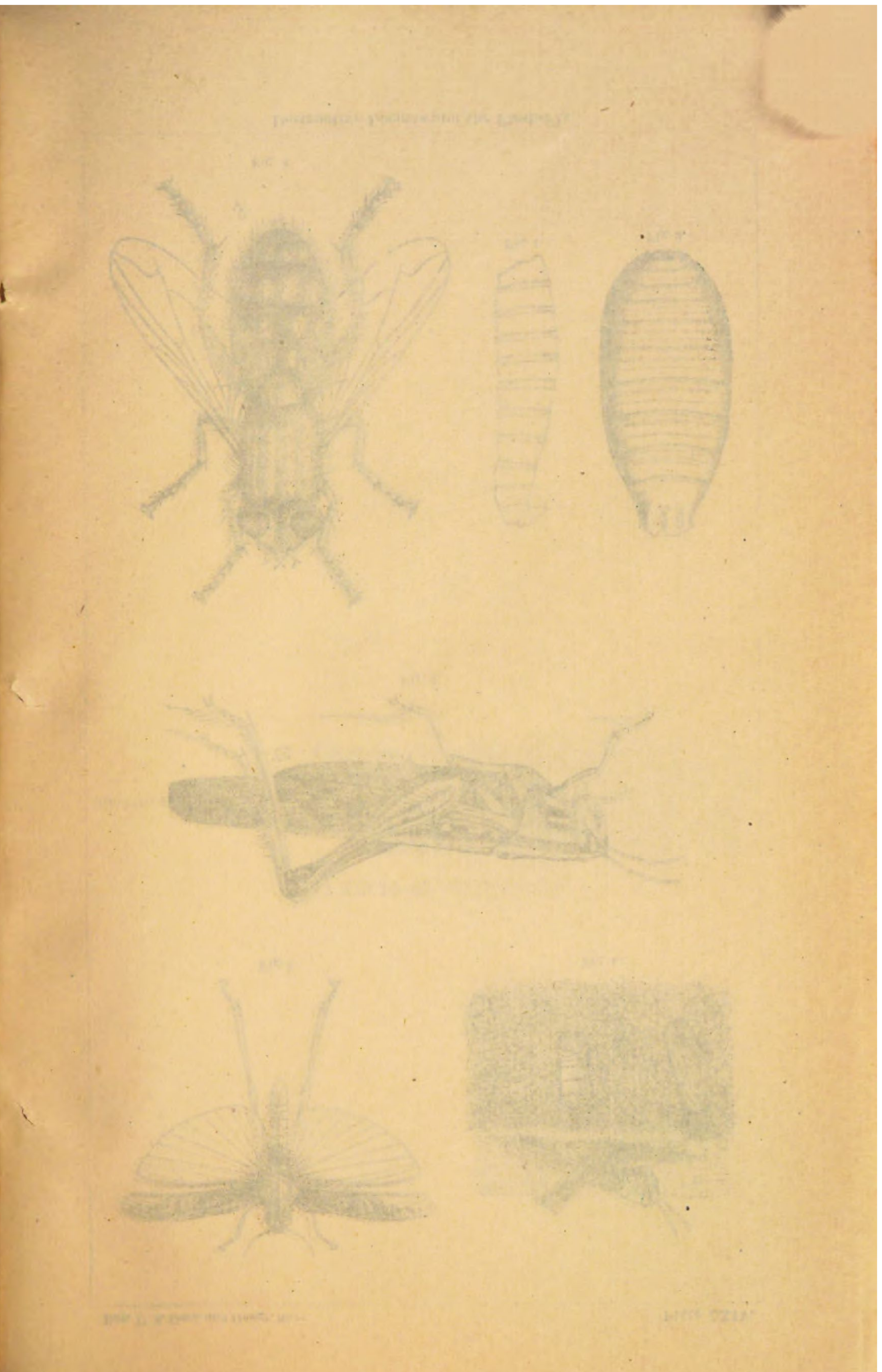


Fig. 2.

Destructive Locusts and the Flesh-Fly.



EXPLANATION OF PLATE LXV.

FIG. 1. Hessian Fly, *Cecidomyia destructor.*—*a*, larva; *b*, pupa; *c*, stalk of wheat, with three cavities containing the larvæ, their heads toward the ground.—(After Fitch.)

FIG. 2. *Agrotis suffusa* Denis and Schiffermüller, and Caterpillar or Cut-Worm.—(After Riley.)

FIG. 3. *Agrotis subgothica.*—(After Riley.)

FIG. 4. *Celæna renigera* Stephens, and Caterpillar.—(After Riley.) A Cut-Worm feeding on the roots of different flowers in gardens.

FIG. 5. *Agrotis cochrani* Riley, and Cut-Worm.—(After Riley.)

FIG. 6. *Gortyna nitela* Guenée, and Larva.—(After Riley.)

FIG. 7. Angoumois Moth, and FIG. 8, its Larva.—(From Guide to Study of Insects.)

FIG. 9. Wheat Tinea, and its larva and chrysalis, natural size and enlarged, with the grains of wheat tied together with silk threads.—(After Curtis.)

FIG. 10. *a*, larva; *b*, pupa; *c*, beetle of *Sitophilus oryzæ* (Linn.), Rice-Weevil; *e*, *Sitophilus granarius* (Linn.), Grain-Weevil.—(After Curtis.)

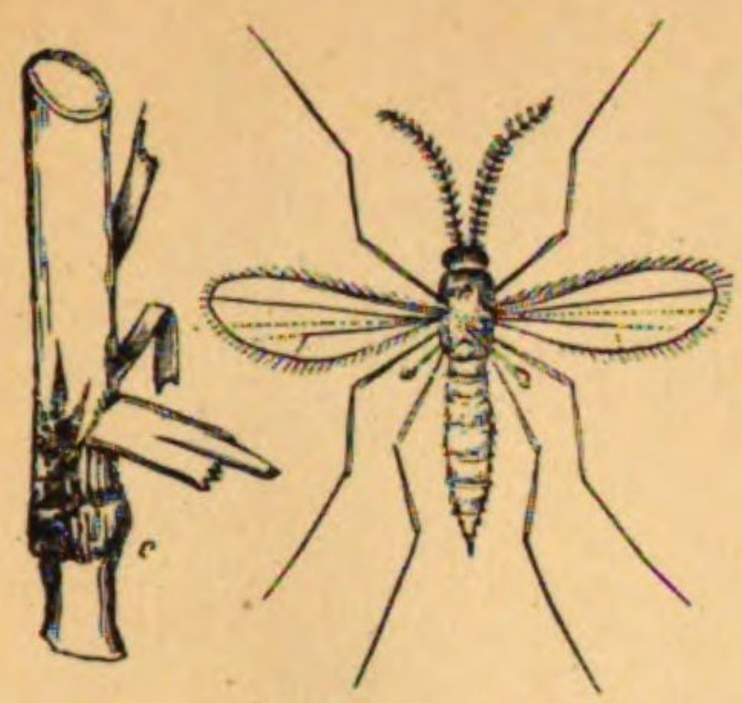


Fig. 1.

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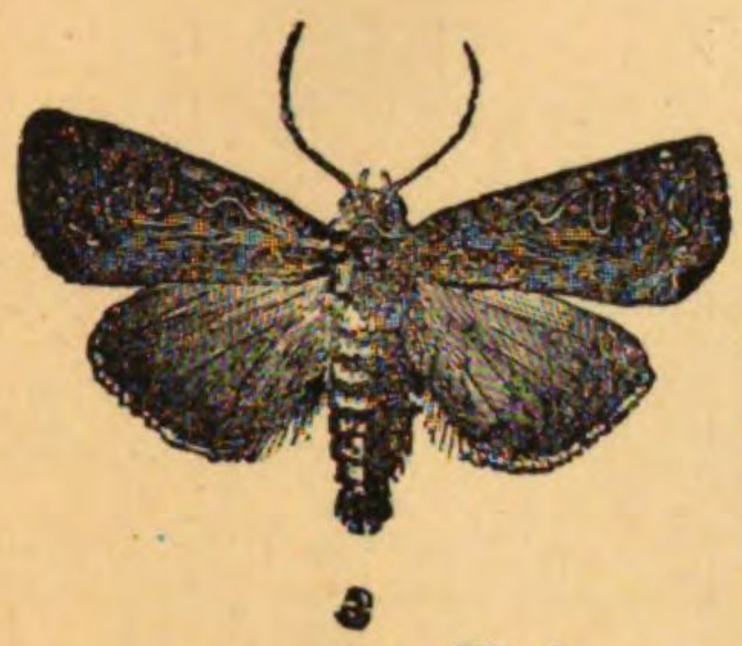


Fig. 3.

Fig 4.

Fig. 5.

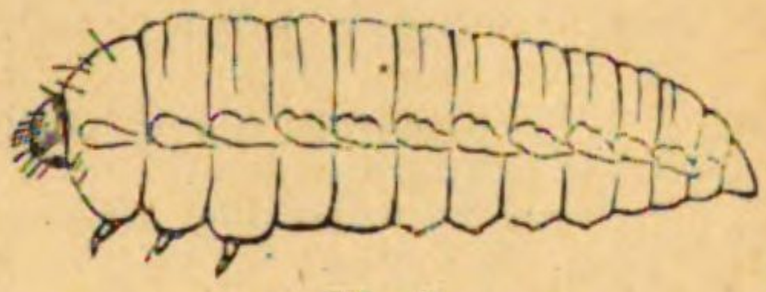


Fig. 8.

Fig. 7.

Fig. 6.

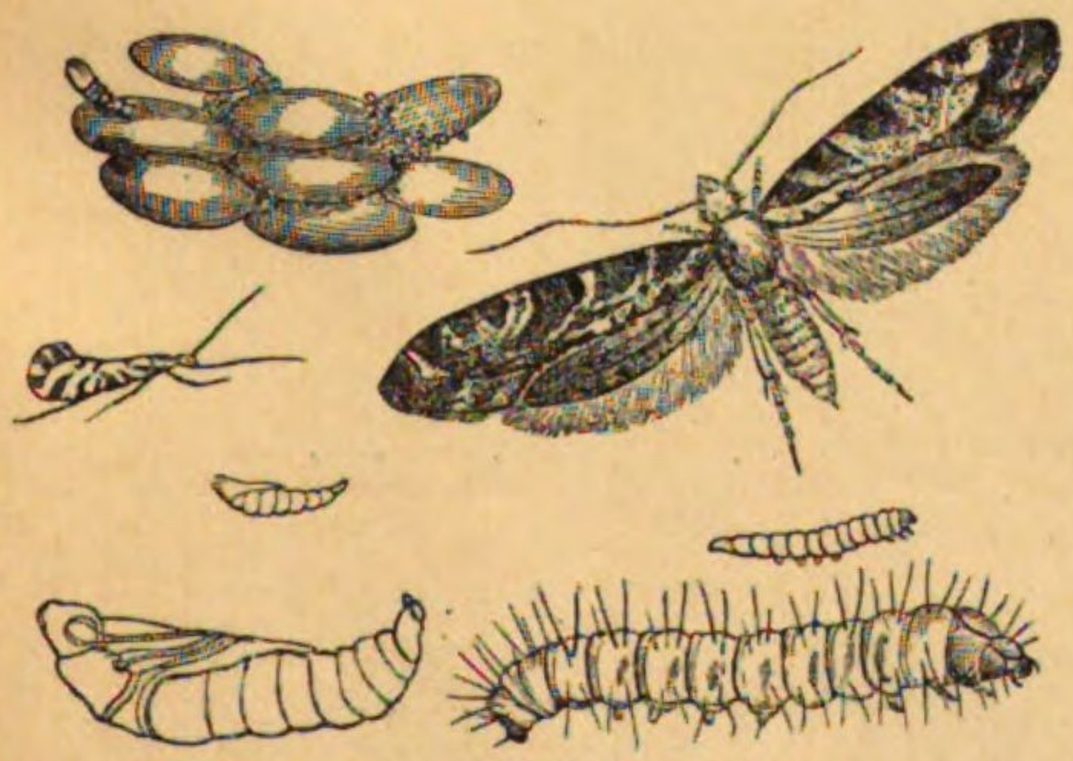


Fig. 9.

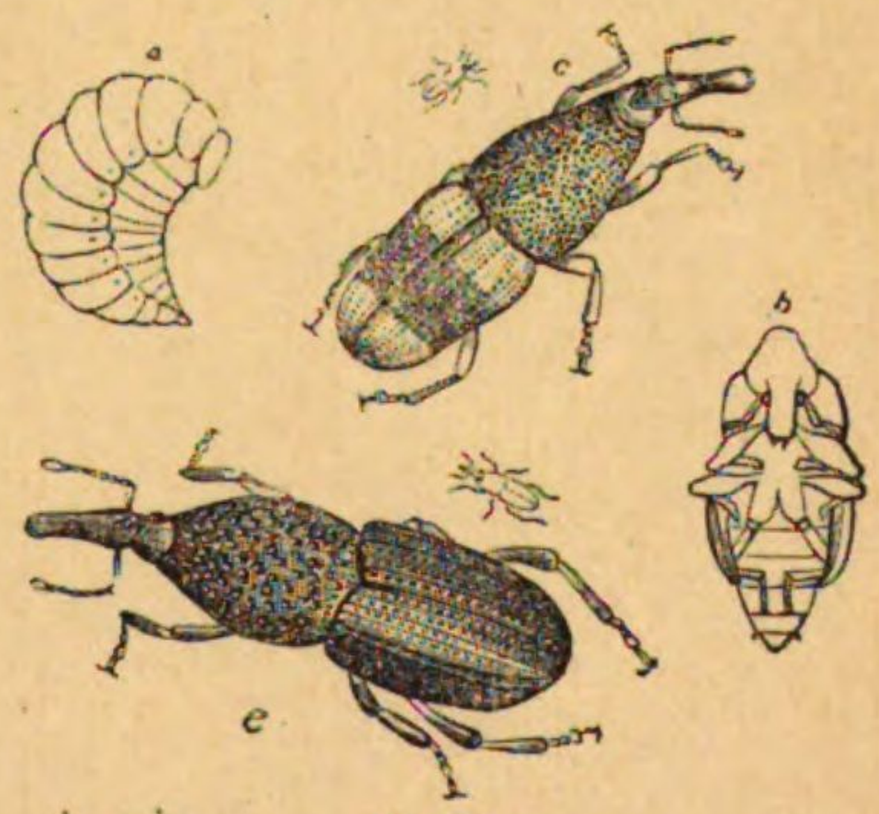


Fig. 10.

Insects injuring Wheat and Corn.

EXPLANATION OF PLATE LXVI.

FIG. 1. The Colorado Potato-Beetle (*Doryphora* 10-*lineata*).—*a*, *a*, eggs; *b*, *b*, *b*, larva in three stages; *c*, pupa or chrysalis; *d*, *d*, beetle; *e*, a wing-cover, enlarged twice.—(After Riley.)

FIG. 2. *Doryphora juncta*.—*a*, *a*, eggs; *b*, *b*, grub or larva; *c*, beetle; *d*, wing-cover, enlarged, showing two of the black stripes joined together.—(After Riley.)

FIG. 3. The Potato Systena (*S. mitis* Lec.), Kingsley del.

FIG. 4. *Lema trilineata*, Eastern Potato-Beetle.

FIG. 5. *Lema trilineata*.—*a*, *a*, small and mature larva; *b*, end of body of larva; *c*, pupa; *d*, eggs.—(After Riley.)

FIG. 6. *a*, *Macrobasis cinerea* (Fabr.).—*d*, male and female antenna, enlarged.—(After Riley.)

FIG. 7. *b*, *Macrobasis murina* (Lec.).—*c*, male and female antennae, enlarged.—(After Riley.)

FIG. 8. *Epicauta marginata* (Fabr.).—Blister-Beetle.

FIG. 9. *Epicauta vittata* (Fabr.).—Blister-Beetle.

FIG. 10. *Epicauta maculata* (Say).—Blister-Beetle. (Kingsley del.)

FIG. 11. *Epicauta pardalis* (Lec.).—Blister-Beetle. (Kingsley del.)

FIG. 12. Potato-Stalk Weevil (*Baridius trinotatus* Say).—*a*, larva; *b*, pupa.—(After Riley.)

FIG. 13. Flea-beetle, *Epitrix cucumeris* (Harris).—(From Harris.)

FIG. 14. *Lygus lineolaris* Beauv.—(After Riley.)

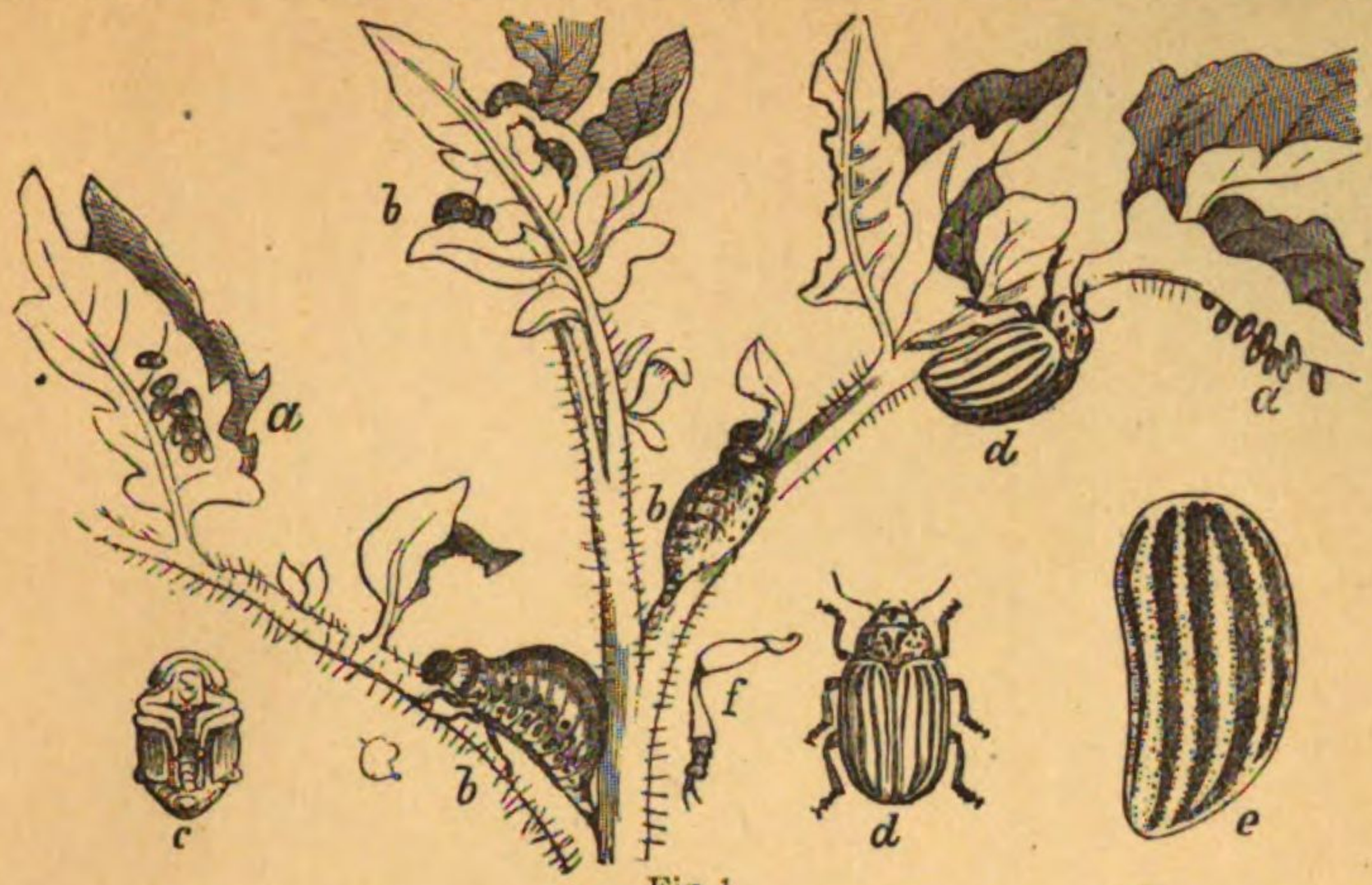


Fig. 1.

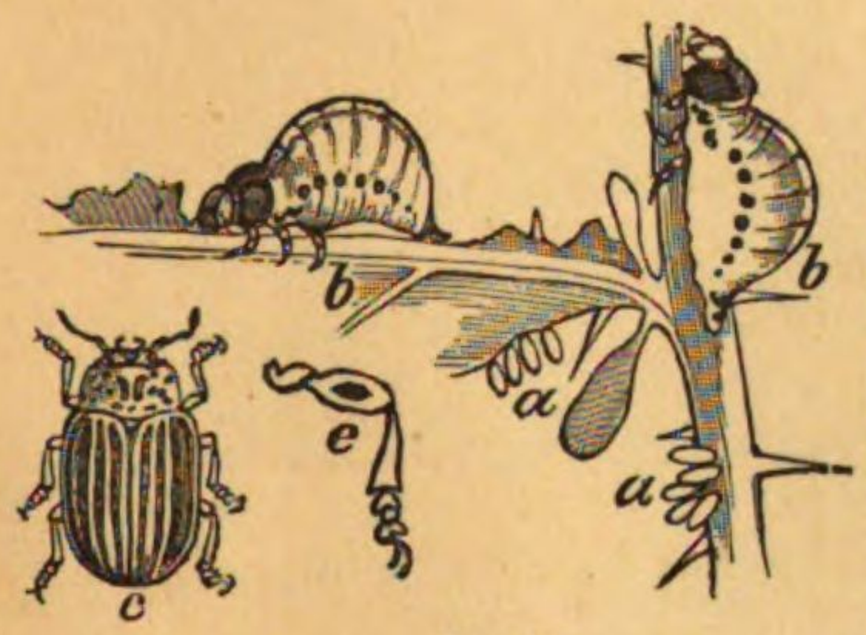


Fig. 2.

Fig. 13.

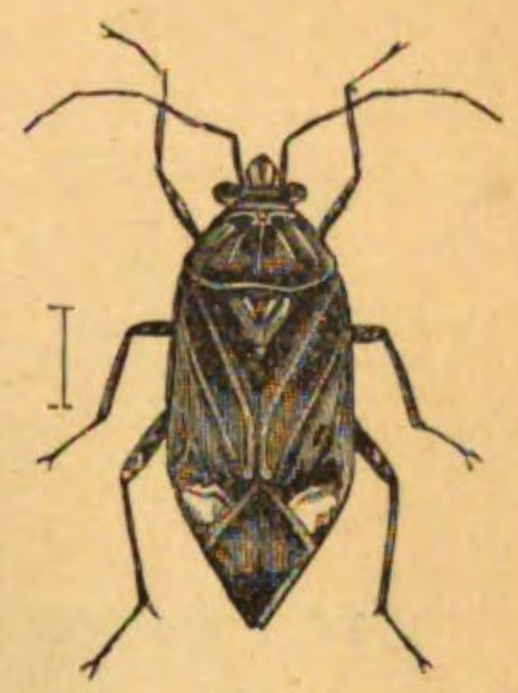


Fig. 14.

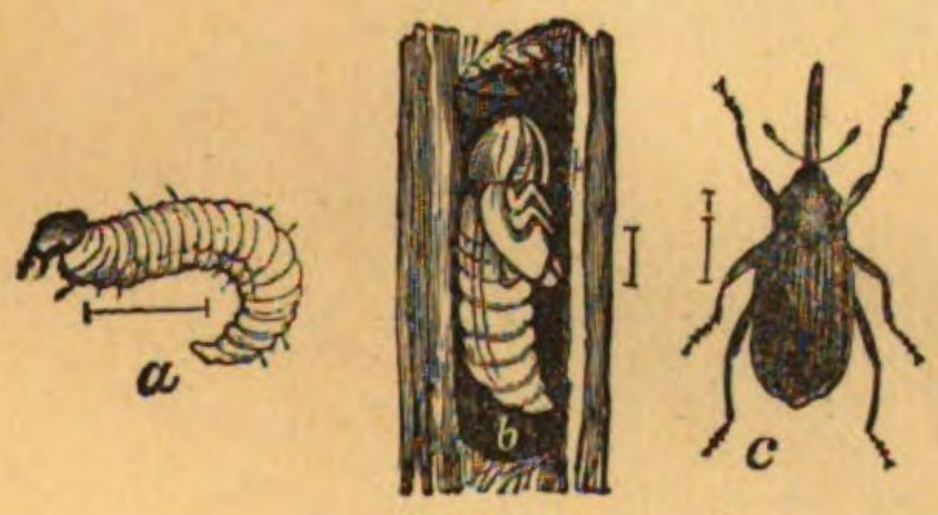


Fig. 12.

Fig. 4.

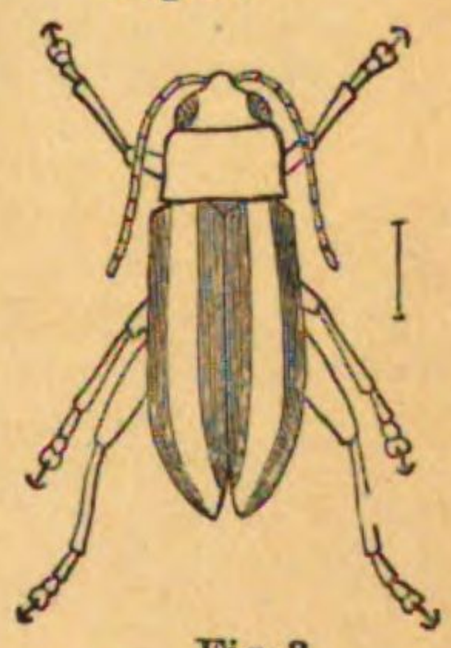


Fig. 3.

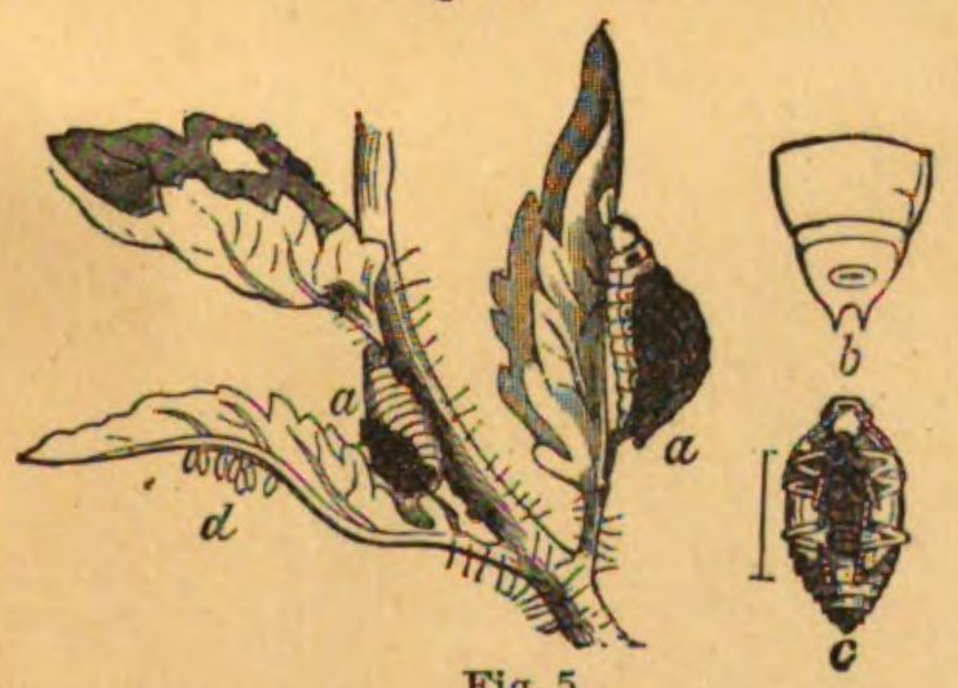


Fig. 5.

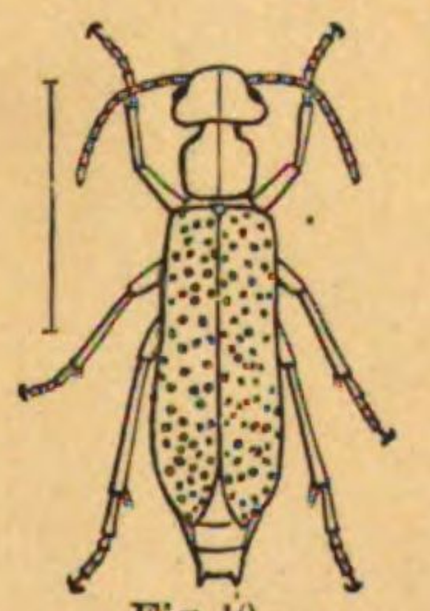


Fig. 10.

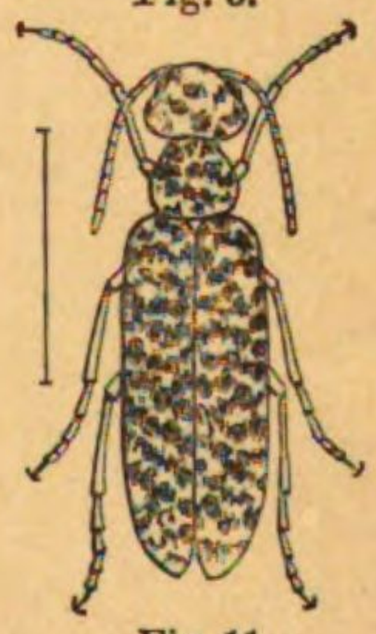


Fig. 11.

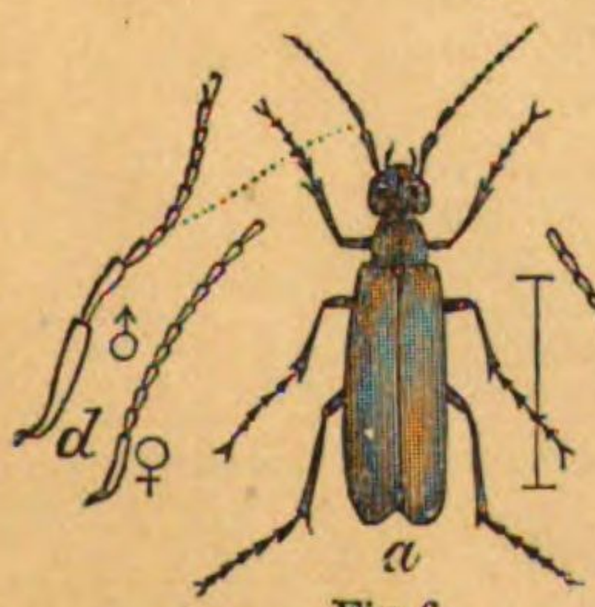


Fig. 6.

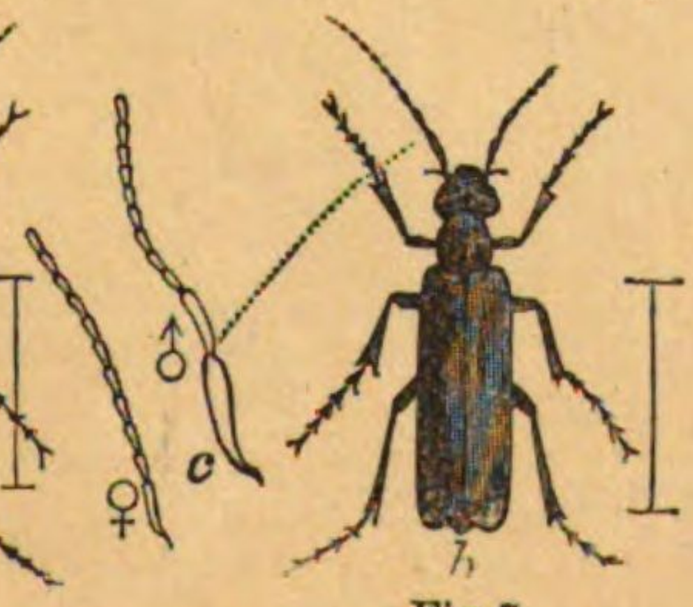


Fig. 7.

Fig. 8.

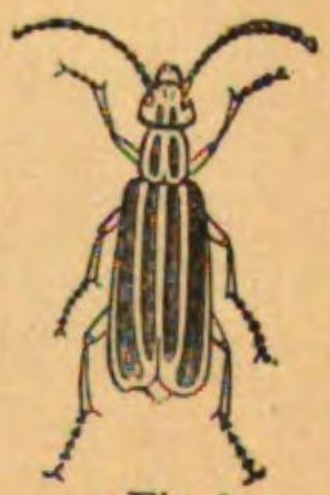


Fig. 9.

Insects injuring the Potato.

EXPLANATION OF PLATE LXVII.

FIG. 1. *Anthomyia ceparum*, Onion Maggot and Fly.
FIG. 2. *Ortalis flexa* Wied., Southern Onion-Worm.
FIG. 3. *Limothrips tritici* Fitch. Female.
FIG. 4. *a*, Male; *b*, larva.
FIG. 5. End of antenna of male *Limothrips tritici*, Onion-Thrips.

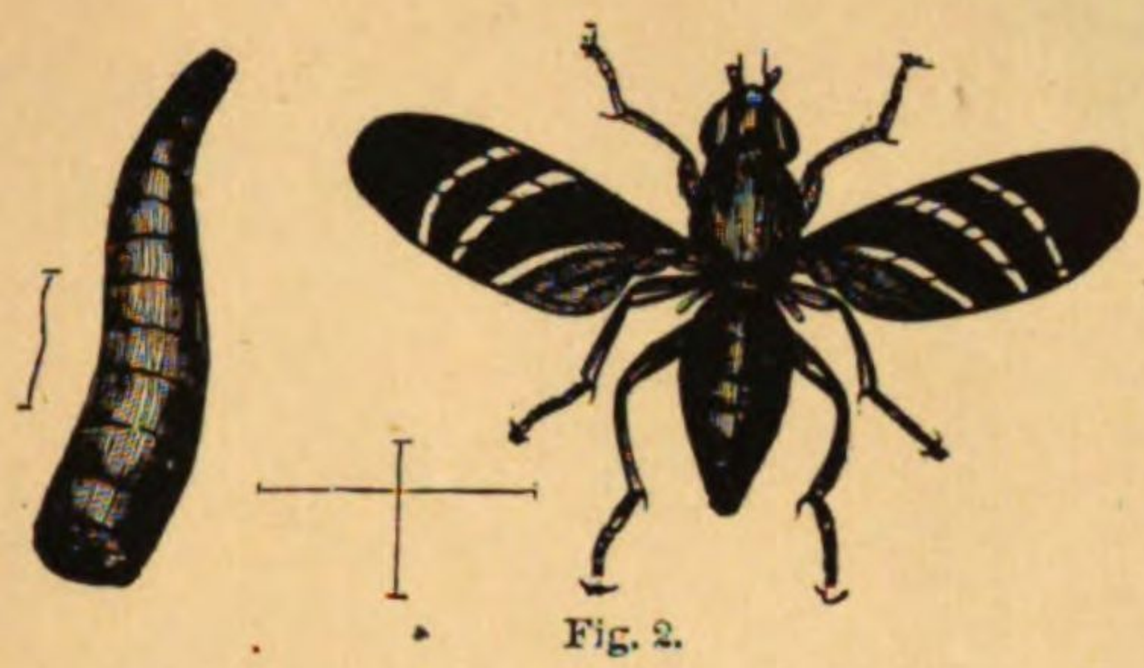


Fig. 2.

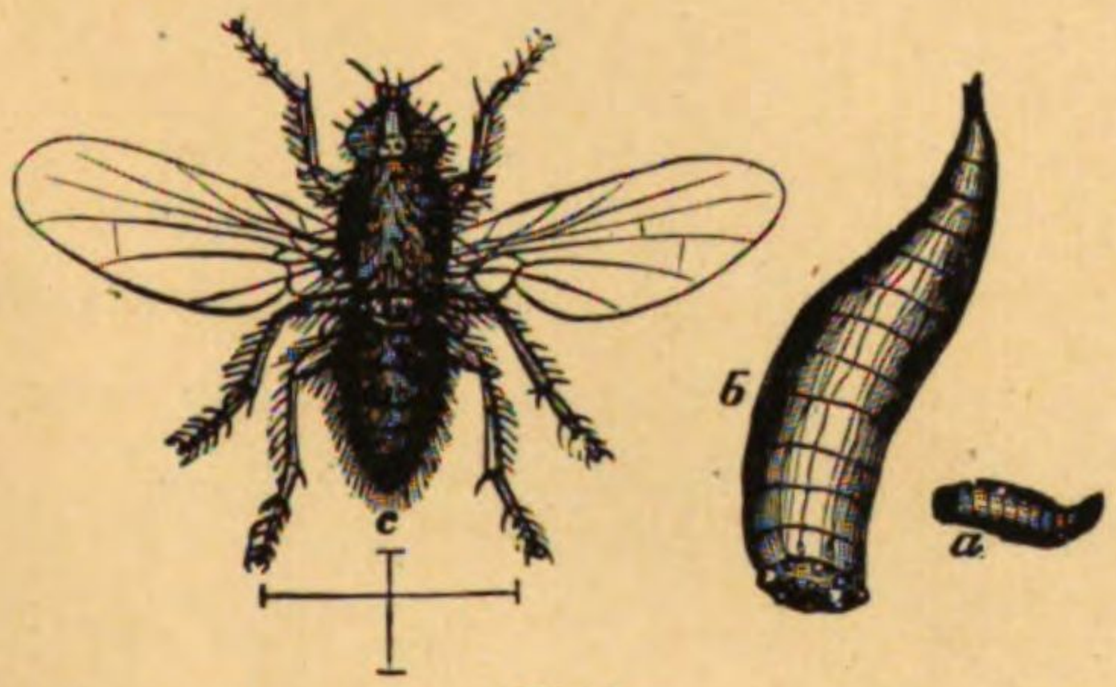


Fig. 1.

Fig. 3.

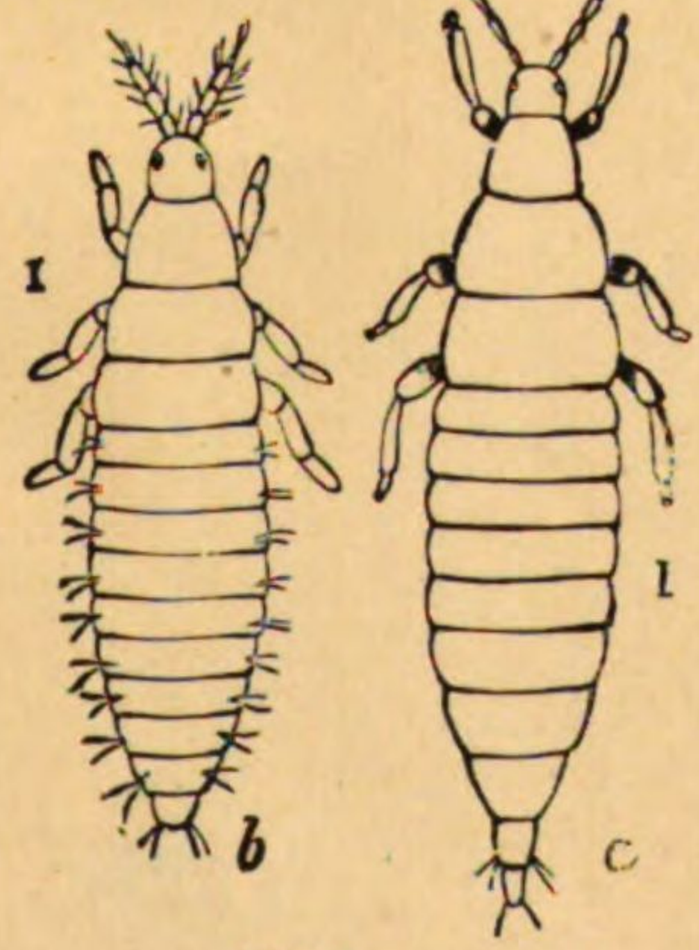


Fig. 4.

Fig. 5.

Insects injurious to the Onion.

EXPLANATION OF PLATE LXVIII.

FIG. 1. Grape Phylloxera.—*a*, shows a healthy root; *b*, one in which the lice are working, representing the knots and swellings caused by their punctures; *c*, a root that has been deserted by them, and where the rootlets have commenced to decay; *d*, *d*, *d*, shows how the lice are found on the larger roots; *e*, female pupa, dorsal view; *f*, the same, ventral view; *g*, winged female, dorsal view; *h*, same, ventral view; *i*, magnified antenna of winged insect; *j*, side view of the wingless female laying eggs on roots; *k*, shows how the punctures of the lice cause the larger roots to decay.—(After Riley.)

FIG. 2. Sexual Phylloxeræ.—*a*, female *vastatrix*, ventral view, showing the egg through the transparent skin of the body; *b*, dorsal view of the same; *c*, tarsus, greatly enlarged; *d*, shrunken anal joints as they appear after oviposition; *e*, male *caryæcaulis*, dorsal view; the dot in the circles indicates the natural size of the insect—(After Riley.)

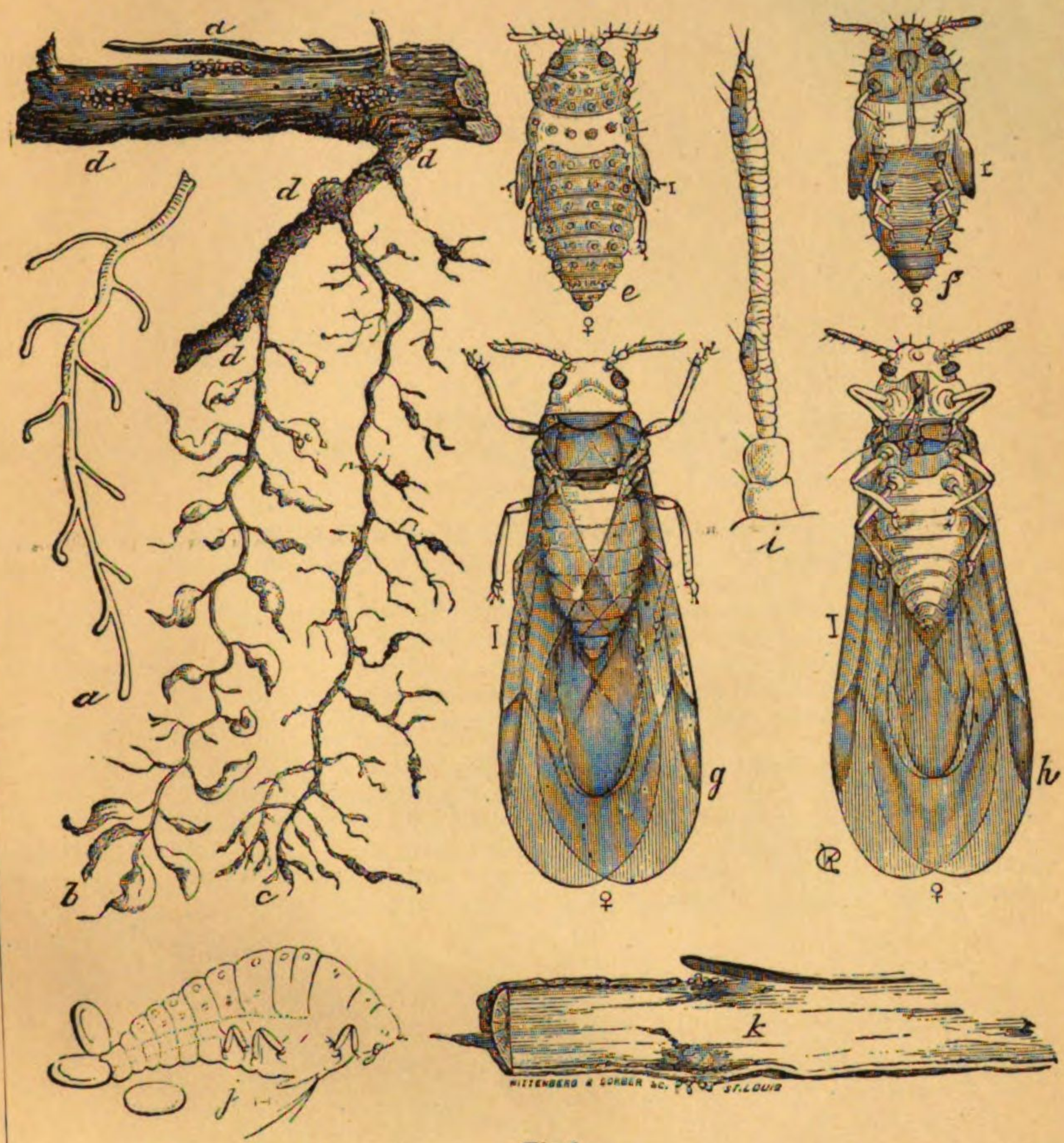


Fig. 1.

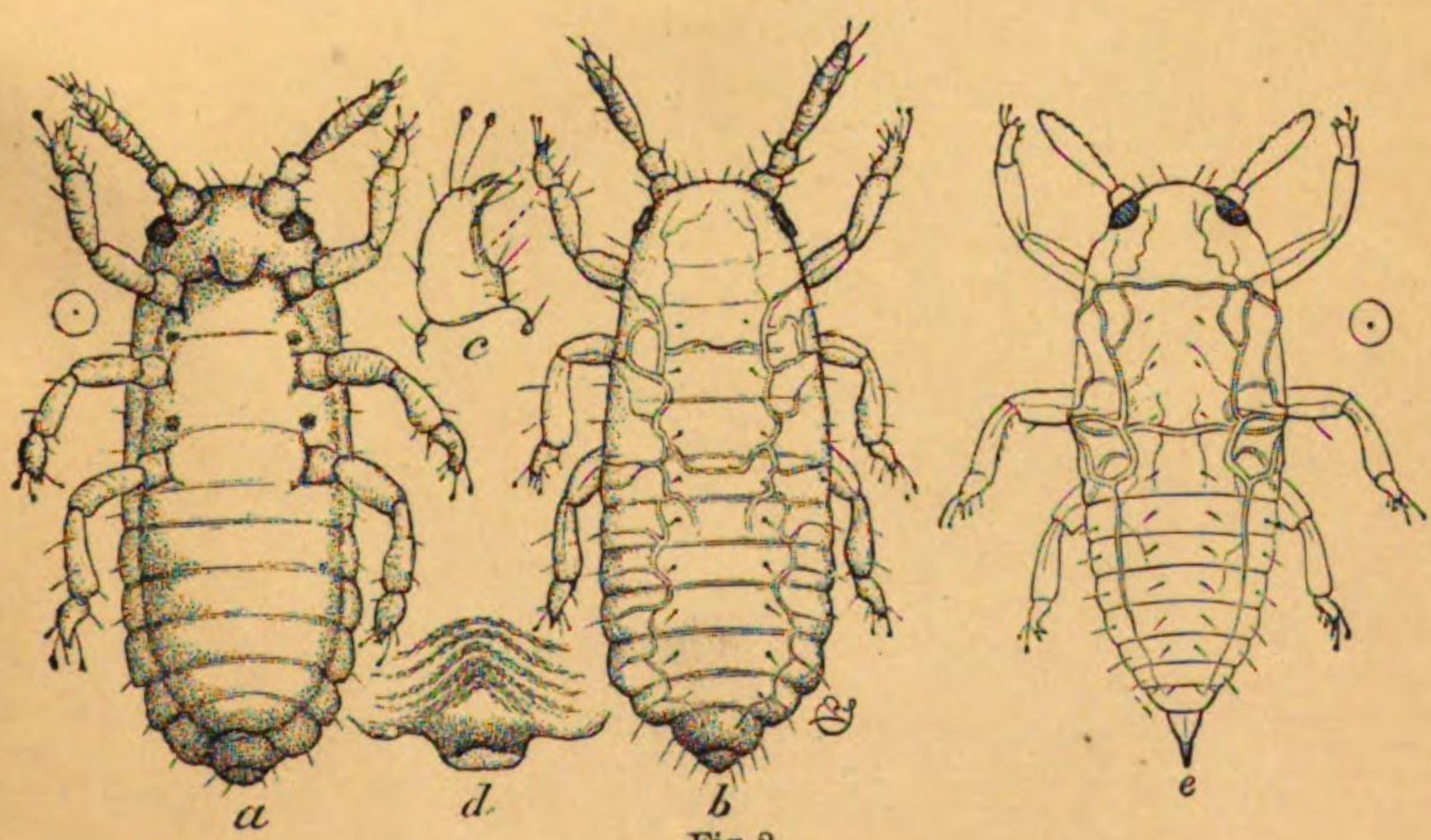


Fig. 2.

The Grape Phylloxera.

EXPLANATION OF PLATE LXIX.

FIG. 1. *Anisopteryx vernata* Peck. Canker-Worm.—*a*, caterpillar; *b*, a mass of eggs natural size, and one much enlarged; *c*, lateral, *d*, dorsal view of a segment enlarged.—(After Riley.)

FIG. 2. *Anisopteryx vernata* Peck.—*a*, male, *b*, female; *c*, three antennal joints; *d*, an abdominal segment showing the two rows of spines not present in the female of *A. autumnata*; *e*, ovipositor.—(After Riley.)

FIG. 3. *Anisopteryx autumnata* (*A. pometaria* of Morrison & Mann).—*a*, *b*, *c*, egg; *c*, *d*, *f*, caterpillar; *g*, *h*, female chrysalis.—(After Riley.)

FIG. 4. *Anisopteryx autumnata*.—*a*, male; *b*, female; *c*, portion of antenna enlarged; *d*, a female abdominal segment, dorsal view, enlarged.—(After Riley.)

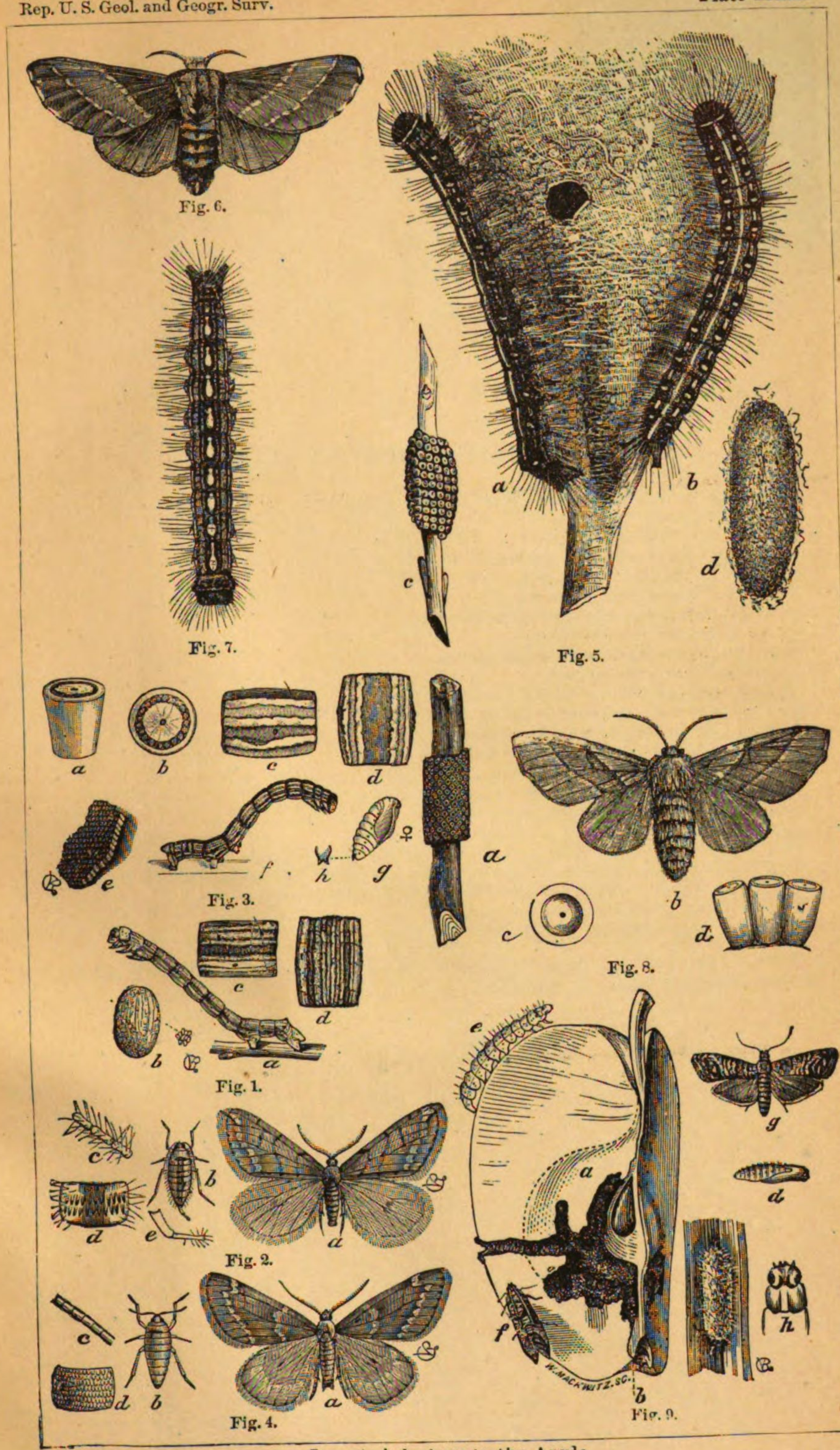
FIG. 5. *Clisiocampa americana*.—*a*, *b*, American Tent-Caterpillar; *c*, eggs; *d*, cocoon.—(After Riley.)

FIG. 6. Female moth of American Tent-Caterpillar.—(After Riley.)

FIG. 7. Caterpillar of *Clisiocampa disstria* Hübner.—(After Riley.)

FIG. 8. *b*, Female *Clisiocampa disstria*; *a*, *c*, *d*, eggs.—(After Riley.)

FIG. 9.—Coddling moth, *Carpocapsa pomonella* Linn.—*a*, apple injured by the caterpillar *e*, which hatches from an egg laid at the point *b*; *d*, chrysalis; *h*, head and next segment of the larva; *f*, *g*, moth; *i*, the cocoon.—(After Riley.)

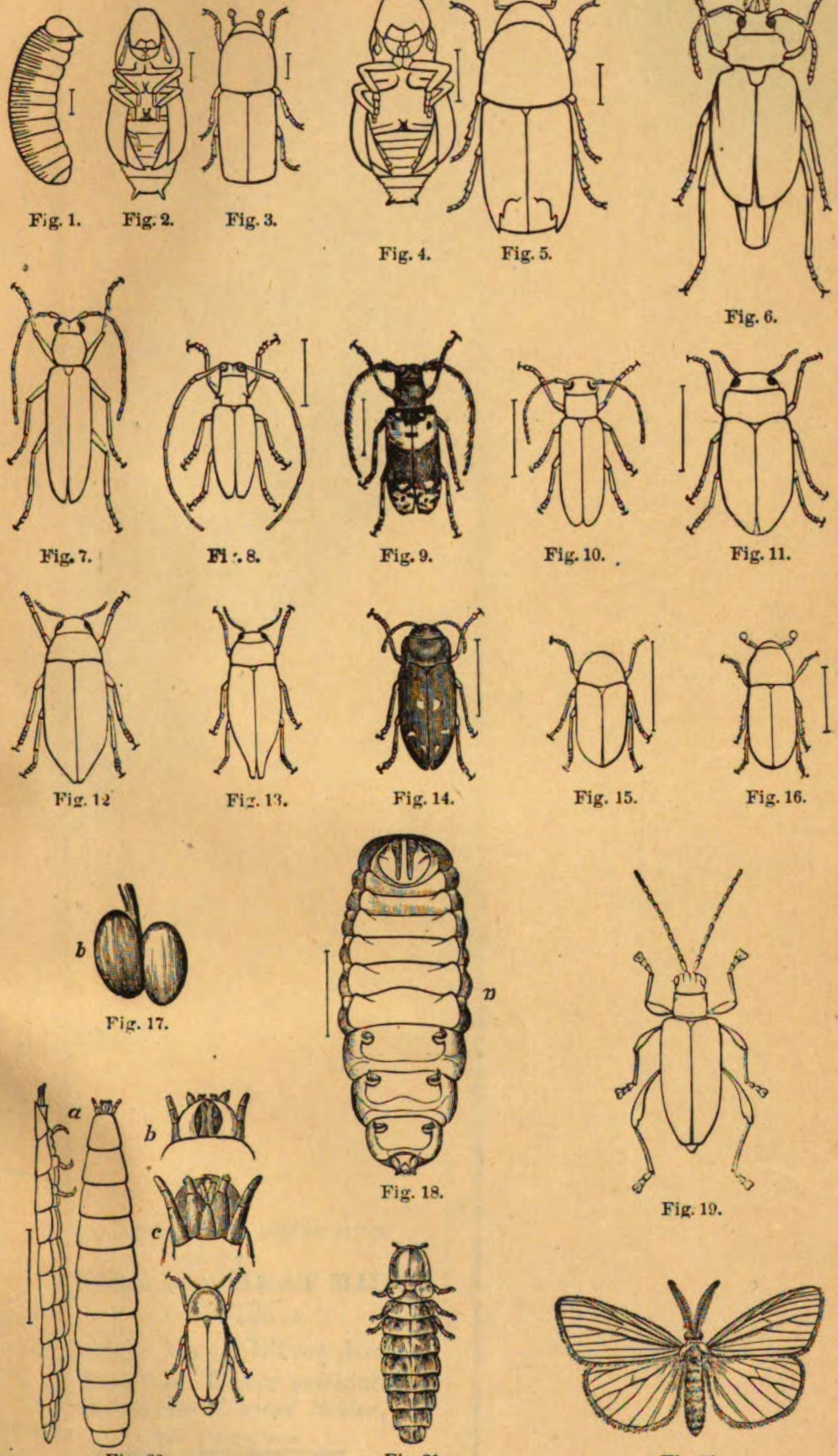


Insects injurious to the Apple.

EXPLANATION OF PLATE LXX.

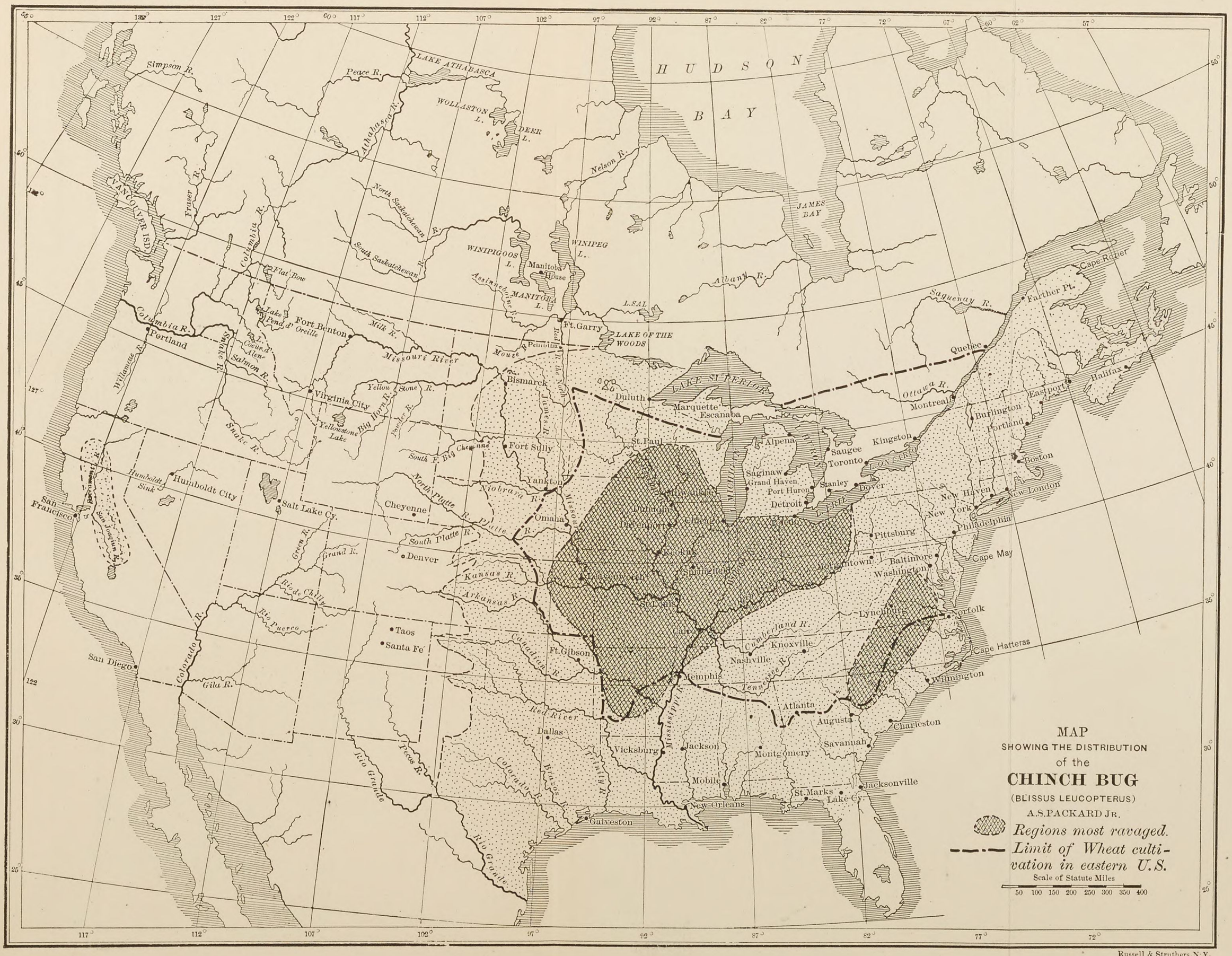
FIG. 1. Larva of *Dryocœtes affaber* Mannh.
FIG. 2. Pupa of the same.
FIG. 3. Adult of the same.
FIG. 4. Pupa of *Tomicus pini* Say.
FIG. 5. Adult of *Tomicus pini*.
FIG. 6. *Prionus emarginatus* Say.
FIG. 7. *Criocephalus productus* Le Conte.
FIG. 8. *Dectes spinosus* (Say).
FIG. 9. *Pogonocherus mixtus* Haldeman.
FIG. 10. *Mecas pergrata* Say.
FIG. 11. *Chrysobothris trinervia* (Kirby).
FIG. 12. *Buprestis rusticorum* Kirby.
FIG. 13. *Dicerca prolongata* Le Conte.
FIG. 14. *Melanophila drummondi* Kirby.
FIG. 15. *Dermestes marmoratus* Say.
FIG. 16. *Dendroctonus obesus* Mannh.
FIG. 17. Cocoon of *Donacia proxima*.
FIG. 18. Larva of *Donacia proxima*.
FIG. 19. Adult (enlarged twice) of *Donacia proxima* Kirby.
FIG. 20. *Pleotomus pallens* Le Conte, male.—*a*, dorsal and side view of the larva; *b*, dorsal, and *c*, ventral view of the mouth-parts.
FIG. 21. Female of *Pleotomus pallens*.
FIG. 22. *Phryganidia californica* Pack.; male.

NOTE.—Figs. 1–16 and 20 were drawn by Mr. J. S. Kingsley, and Figs. 17–19, 21, and 22 were drawn by Mr. J. H. Emerton.



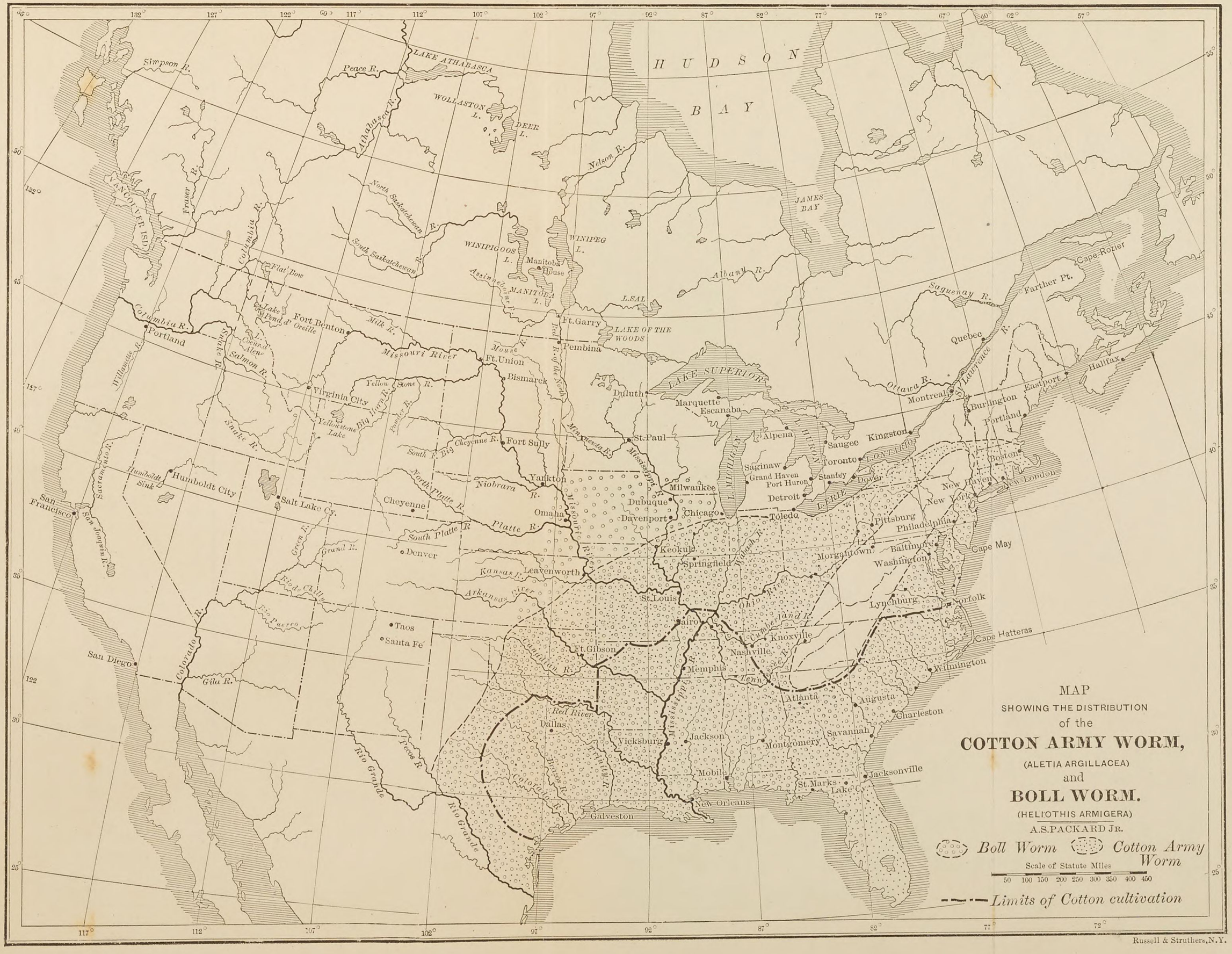
Insects injurious to Western Forest Trees.

MAP
SHOWING APPROXIMATE DISTRIBUTION
of the
HESSIAN FLY & WHEAT MIDGE.
A.S.PACKARD JR.
Hessian Fly
Wheat Midge
Limit of Wheat cultivation in eastern United States,
Scale of Statute Miles
50 100 150 200 250 300 350 400
HUDSON BAY
JAMES BAY
LAKE ATHABASCA
WOLLASTON L.
DEER L.
WINNIPEGOOS L.
WINNIPEG L.
MANITOBA L.
LAKE OF THE WOODS
L. SUPERIOR
L. MICHIGAN
L. HURON
L. ERIE
L. ONTARIO
L. SAL
VANCOUVER ISD.
Simpson R.
Peace R.
Athabasca R.
Nelson R.
Fraser R.
Columbia R.
North Saskatchewan R.
South Saskatchewan R.
Assiniboine R.
Albany R.
Saguenay R.
St. Lawrence R.
Ottawa R.
Cape Rozier
Farther Pt.
Quebec
Montreal
Halifax
Eastport
Burlington
Portland
Boston
New London
New Haven
New York
Philadelphia
Cape May
Baltimore
Washington
Norfolk
Cape Hatteras
Wilmington
Charleston
Savannah
Augusta
Atlanta
Jacksonville
St. Marks
Lake Cy
Mobile
Montgomery
Jackson
New Orleans
Galveston
Vicksburg
Memphis
Nashville
Knoxville
Lynchburg
Cario
St. Louis
Keokuk
Springfield
Leavenworth
Dubuque
Davenport
Chicago
Milwaukee
Toledo
Detroit
Port Huron
Grand Haven
Saginaw
Alpena
Escanaba
Marquette
Duluth
Stanley
Dover
Toronto
Saugee
Kingston
Pittsburg
Morgantown
Ft. Garry
Pembina
Ft. Union
Bismarck
Ft. Sully
Yankton
Omaha
Cheyenne
Denver
Salt Lake Cy.
Humboldt City
Humboldt Sink
San Francisco
San Diego
Portland
Virginia City
Yellowstone Lake
Fort Benton
Flat Bow
Lake Pend d'Oreille
L. Coeur d'Alen
Salmon R.
Snake R.
Milk R.
Missouri River
Yellow Stone R.
Big Horn R.
Powder R.
Cheyenne R.
South F. Big Cheyenne R.
Niobrara R.
North Platte R.
Platte R.
South Platte R.
Kansas R.
Arkansas R.
Canadian R.
Red R.
Dallas
Ft. Gibson
Taos
Santa Fe
Colorado R.
Gila R.
Rio Grande
Pecos R.
Brazos R.
Trinity R.
Mississippi R.
Red R. of the North
Mouse R.
Minnesota R.
Ohio R.
Cumberland R.
Tennessee R.
Green R.
Grand R.
Rio de Chillu
Rio Puerco
Sacramento R.
San Joaquin R.
Humboldt R.
Williamette R.
Columbia R.



Russell & Struthers.N.Y.

MAP
SHOWING THE DISTRIBUTION
of the
NORTHERN ARMY WORM
(HELIOPHILA UNIPUNCTA)
A.S.PACKARD JR.
Regions most ravaged.
Limit of Wheat cultivation in Eastern United States
Scale of Statute Miles
50 100 150 200 250 300 350 400
HUDSON BAY
JAMES BAY
LAKE ATHABASCA
WOLLASTON L.
DEER L.
WINIPEG L.
WINIPIGOOS L.
MANITOBA L.
LAKE OF THE WOODS
LAKE SUPERIOR
VANCOUVER ISD.
Simpson R.
Peace R.
Athabasca R.
Nelson R.
Fraser R.
Columbia R.
North Saskatchewan R.
South Saskatchewan R.
Assiniboine R.
Albany R.
Saguenay R.
Ottawa R.
Flat Bow
Lake Pend d' Oreille
Fort Benton
Milk R.
Missouri River
Mouse R.
Red R. of the North
Ft. Garry
Pembina
Ft. Union
Bismarck
Portland
Willamette R.
Snake R.
Salmon R.
L. Coeur d' Alene
Virginia City
Yellowstone Lake
Yellow Stone R.
Big Horn R.
Powder R.
Fort Sully
Cheyenne R.
South F. Big
Yankton
Niobrara R.
Humboldt Sink
Humboldt City
Salt Lake Cy.
Cheyenne
North Platte R.
Platte R.
Omaha
Missouri R.
Sacramento R.
San Francisco
San Joaquin R.
Green R.
Grand R.
South Platte R.
Denver
Kansas R.
Arkansas R.
Rio de Chilly
Rio Puerco
Taos
Santa Fe
Colorado R.
San Diego
Gila R.
Canadian R.
Ft. Gibson
Red R.
Dallas
Pecos R.
Rio Grande
Colorado
Brazos R.
Trinity R.
Galveston
Vicksburg
Jackson
Mobile
New Orleans
Mississippi R.
Memphis
Nashville
Knoxville
Cumberland R.
Ohio River
Wabash R.
Cairo
St. Louis
Springfield
Leavenworth
Keokuk
Davenport
Dubuque
Milwaukee
Chicago
Minnesota R.
St. Paul
Duluth
Marquette
Escanaba
Alpena
Saginaw
Grand Haven
Port Huron
Detroit
Toledo
Stanley
Dover
Saugee
Toronto
Kingston
Montreal
Quebec
Farther Pt.
Cape Rozier
Halifax
Eastport
Portland
Burlington
Boston
New London
New Haven
New York
Philadelphia
Pittsburg
Morgantown
Baltimore
Washington
Cape May
Norfolk
Lynchburg
Cape Hatteras
Wilmington
Charleston
Savannah
Augusta
Atlanta
Montgomery
Jacksonville
St. Marks
Lake Cy.


MAP
SHOWING THE DISTRIBUTION
of the
COTTON ARMY WORM,
(ALETIA ARGILLACEA)
and
BOLL WORM.
(HELIOTHIS ARMIGERA)
A.S.PACKARD JR.
Boll Worm
Cotton Army Worm
Scale of Statute Miles
50 100 150 200 250 300 350 400 450
Limits of Cotton cultivation
HUDSON BAY
JAMES BAY
LAKE ATHABASCA
WOLLASTON L.
DEER L.
WINIPEG L.
WINIPIGOOS L.
MANITOBA L.
LAKE OF THE WOODS
LAKE SUPERIOR
L. MICHIGAN
L. HURON
L. ERIE
L. ONTARIO
VANCOUVER ISD.
Simpson R.
Peace R.
Athabasca R.
Nelson R.
Albany R.
Saguenay R.
Ottawa R.
St. Lawrence R.
Fraser R.
Columbia R.
North Saskatchewan R.
South Saskatchewan R.
Assinneboine R.
Red R. of the North
Mouse R.
Milk R.
Missouri River
Yellow Stone R.
Big Horn R.
Powder R.
Snake R.
Salmon R.
Willamette R.
Sacramento R.
Humboldt Sink
Humboldt City
Salt Lake Cy.
Green R.
Grand R.
Rio de Chilly
Rio Puerco
Colorado R.
Gila R.
Rio Grande
Pecos R.
Arkansas River
Kansas R.
Platte R.
South Platte R.
North Platte R.
Niobrara R.
South F. Big Cheyenne R.
Minnesota R.
Mississippi R.
Wabash R.
Ohio River
Cumberland R.
Tennessee R.
Canadian R.
Red River
Trinity R.
Brazos R.
Colorado R.
Portland
Fort Benton
Virginia City
Yellowstone Lake
Fort Sully
Bismarck
Ft. Union
Ft. Garry
Pembina
Duluth
Marquette
Escanaba
St. Paul
Milwaukee
Chicago
Dubuque
Davenport
Keokuk
Springfield
St. Louis
Cairo
Ft. Gibson
Memphis
Nashville
Knoxville
Atlanta
Augusta
Savannah
Charleston
Wilmington
Jacksonville
St. Marks
Lake Cy.
Mobile
Montgomery
Jackson
Vicksburg
New Orleans
Galveston
Dallas
Taos
Santa Fé
Denver
Cheyenne
Omaha
Yankton
Leavenworth
Alpena
Saginaw
Grand Haven
Port Huron
Detroit
Toledo
Saugee
Toronto
Stanley
Dover
Kingston
Montreal
Quebec
Burlington
Portland
Eastport
Halifax
Boston
New Haven
New London
New York
Pittsburg
Philadelphia
Baltimore
Washington
Morgantown
Lynchburg
Norfolk
Cape May
Cape Hatteras
Cape Rozier
Farther Pt.
San Francisco
San Diego
Russell & Struthers, N.Y.

Russell & Struthers, N.Y.

APPENDIX.

LIST OF COLEOPTERA COLLECTED IN 1875, IN COLORADO AND UTAH, BY A. S. PACKARD, JR., M. D.

The collection of beetles which I made in the summer of 1875, while attached to Professor Hayden's Survey, was submitted to Dr. G. H. Horn for examination and identification.

CICINDELIDÆ.

Cicindela longilabris Say. Georgetown, Colo.
Cicindela punctulata Fabr. Garden of the Gods, Colo.
Cicindela repanda Dej. Boulder, Colo.
Cicindela hæmorrhagica Lec. Salt Lake Point.

CARABIDÆ.

Carabus tædatus Fabr. Kelso's Cabin, foot of Gray's Peak, elevation 11,200 feet; Idaho Springs, Colo.
Pasimachus elongatus Lec. Denver, June 27.
Brachinus minutus Harr. Denver, Colo.
Calathus dubius Lec. Idaho Springs, Colo.
Platynus placidus (Say). Idaho Springs, Colo.
Pterostichus luczotii (Dej.). Idaho Springs, Colo.; Georgetown, Colo., 9,000 feet elevation.
Pterostichus riparius (Dej.). Gray's Peak, at an elevation of about 12,000 feet.
Amara terrestris Lec. Idaho Springs, Colo.
Amara brunnipennis Dej. Arapahoe Peak, 11,000–12,000 feet elevation; summit of Pike's Peak and lower down, about 13,000 feet elevation.
Amara interstitialis Dej. Idaho Springs, Colo.
Amara obesa Say. Idaho Springs, Colo.; Manitou, July 12; Golden, Colo.
Amara avida (Say). Idaho Springs, Colo.
Dicaelus sculptilis Say. Manitou, Colo.
Nothopus zabroides (Lec.). Denver, Colo.
Harpalus pensylvanicus (Dej.). Denver, Colo.; Salt Lake City, Utah.
Harpalus furtivus Lec. Golden, Colo.; Idaho Springs, Colo.; Manitou, Colo., July 12.
Harpalus fallax Lec. Idaho Springs; Kelso's Cabin, Gray's Peak, 11,200 feet elevation, July 6.
Harpalus oblitus Lec. Idaho Springs, Colo.; Manitou, Colo.
Cratacanthus dubius (Beauv.). Denver, Colo., June 27.
Agonoderus comma (Fabr.). Denver; Idaho Springs, Colo.
Discoderus parallelus (Hald.). Shores of Great Salt Lake at Lake Point, Utah.
Patrobus longicornis (Say). Boulder, Colo.
Patrobus aterrimus Dej. Idaho Springs, Colo.

Bembidium bimaculatum (Kirby). Idaho Springs, Colo.
Bembidium rupestre Dej. Idaho Springs, Colo.
Bembidium bifossulatum Sec. Denver, Col.

DYTISCIDÆ.

Hydroporus vilis Lec. Colorado.
Hydroporus sellatus Lec. Denver, Colo.
Ilybius confusus Aubé. Denver, Colo.
Gaurodytes disintegratus Cr. Denver.

HYDROPHILIDÆ.

Helophorus lineatus Say. Arapahœ Peak, 11,000–12,000 feet elevation.
Tropisternus lateralis Hb. Denver.
Berosus styliferus Horn. Denver.

STAPHYLINIDÆ.

Creophilus villosus (Grav.). Georgetown, Colo.; Lake Point, margin of Great Salt Lake, Utah.
Philonthus californicus Mann. Margin of Great Salt Lake, Utah.
Philonthus pœderoides Lec. Colorado.
Philonthus sp. Idaho Springs, Colo.
Tachinus sp. Idaho Springs, Colo.

SILPHIDÆ.

Silpha lapponica Hb. Idaho Springs, Colo.
Catops sp.

DERMESTIDÆ.

Dermestes marmoratus Say. Utah. Mr. Barfoot.
Cryptorhopalum ruficorne Lec. Garden of the Gods.

NITIDULIDÆ.

Carpophilus pallipennis (Say). Denver.

COCCINELLIDÆ.

Coccinella 5-notata Kirby. Idaho Springs, Colo.
Coccinella 9-notata Hb. Denver, Colo.
Hippodamia 5-signata (Kirby). Denver; American Fork Cañon, Utah.
Hippodamia convergens Guér. Denver, Colo.
Hippodamia parenthesis (Say). Manitou, Colo.

HISTERIDÆ.

Saprinus lugens Er. Margin of Great Salt Lake, Utah.
Saprinus estriatus Lec. Margin of Great Salt Lake, Utah.

SCARABÆIDÆ.

Canthon hudsonias (Forst.). Denver, Colo.
Canthon ebenus (Say). Denver, Colo.

Rhyssemus scaber Haed.
Diplotaxis obscura Lec. Utah (Mr. Barfoot).
Polyphylla decemlineata (Say). Utah (Mr. Joseph L. Barfoot).
Cotalpa lanigera (Linn.). Utah (Mr. Barfoot).
Tostegoptera lanceolata (Say). Boulder, Garden of the Gods.
Liggrus gibbosus (De Geer). Denver, June 27; Utah (Mr. Barfoot).
Euryomia inda (Linn.).
Trichius piger Fabr. Manitou, Colo., July 15.

BUPRESTIDÆ.

Buprestis lauta Lec. Utah (Mr. Barfoot).
Buprestis rusticorum Kirby. Manitou, Colo., July 16.
Dicerca prolongata Lec. Denver, Colo.; Idaho Springs, on populus, July 6.
Melanophila drummondi (Kirby). American Fork Cañon, Utah.
Chrysobothris trinervia (Kirby). The Divide (on the railroad), Colorado, July 12.
Acmæodera mixta Lec. Manitou, and Garden of the Gods, July 15.

ELATERIDÆ.

Asaphes coracinus Cand. Golden, Colo.
Melanotus castanipes (Payk).

LAMPYRIDÆ.

Photinus nigricans (Say).

TELEPHORIDÆ.

Podabrus (near puncticollis Kirby). Gray's Peak, about 12,000 feet.
Podabrus (not determined). Georgetown, Colo.

MALACHIDÆ.

Collops vittatus Say? var. shore of Great Salt Lake, Salt Lake Point, July 26.
Dasytes hudsonicus Lec.
Pristocelis antennatus (Motsch). Golden, Colo.

CLERIDÆ.

Clerus ornatus (Say). Georgetown, Colo., on flowers, July 8.

PTINIDÆ.

Dinoderus cribratus Lec. Boulder, Colo.

CERAMBYCIDÆ.

Prionus californicus Motsch. Salt Lake City (Mr. Barfoot).
Prionus emarginatus Say. Salt Lake City (Mr. Barfoot).
Asemum moestum Hald. Mederland, Colo., June 30.
Criocephalus productus Lec. Colorado. Shores of Great Salt Lake.
Batyle ignicollis (Say). Golden; Garden of the Gods, July 13.

Batyle suturalis (Say). Denver; Garden of the Gods, July 13.
Neoclytus muricatulus (Kirby). Boulder, Colo.
Acmæops pratensis (Laich.). Manitou, Colo.; Georgetown, Colo., 9,500 feet elevation, July 8; Pike's Peak, summit and 13,000 feet elevation; Arapahoe Peak, 11,000–12,000 feet elevation.
Acmæops proteus (Kirby). Georgetown, Colo., 9,000 feet elevation, July 6.
Pachyta nitens Kirby. Georgetown, Colo.
Leptura chrysocoma Kirby. Manitou, July 15.
Leptura sanguinea Le Conte. Manitou.
Dectes spinosus (Say). Denver, Manitou.
Pogonocherus mixtus Hald. Idaho Springs, July 5, on populus.
Mecas pergrata (Say). Denver.
Tetraopes basalis Lec. Common in gardens in Salt Lake City, Utah.

CHRYSOMELIDÆ.

Coscinoptera dominicana (Fabr.).
Pachybrachys (not described), American Fork Cañon, Utah.
Chrysochus cobaltinus Lec. Denver, Colo., Salt Lake City (Mr. Barfoot).
Chrysomela 10-lineata (Say). Common; eggs, larva, and imago. Golden, Denver.
Chrysomela adonidis Fab. Georgetown, Colo., about 9,000 feet elevation.
Chrysomela scripta Fabr. (var. *confluens* Rog.). American Fork Cañon, Utah.
Chrysomela exclamationis Fabr. Denver, Colo.
Graptodera punctipennis Lec. Idaho Springs, Colo.
Graptodera plicipennis (Mann.). Manitou, Colo.
Graptodera (not determined).
Luperus meraca Say. (Does not appear to differ from "*meraca*" Horn.). Georgetown, Colo., 9,000 feet elevation.
Orchestris albionica (Lec.). Idaho Springs, Colo., July 6; Pike's Peak, on summit, abundant.
Orchestris ? Denver.
Systena mitis Lec. var. *ligata* Lec. Idaho Springs, Colo., July 5, on potato-vines.

TENEBRIONIDÆ.

Eusattus muricatus Lec. Utah (Mr. Barfoot).
Coniontis obesa Lec. Manitou.
Eleodes extricata (Say). Denver, Manitou, Idaho Springs.
Eleodes pimelioides Mann. Idaho Springs, Colo.
Eleodes suturalis (Say). Denver, June 27.
Eleodes nigrina Lec. Idaho Springs, Colo.
Eleodes planipennis Lec. Manitou, Colo.
Eleodes quadricollis Esch. Manitou.
Eleodes tricostata (Say). Kansas Pacific Railroad, Colorado, June 26.
Embaphion elongatum Horn. Utah (Mr. Barfoot).
Iphthimus serratus (Mann.) var. *Lewisii* Horn. Blackhawk, Colo.

MORDELLIDÆ.

Diclidia lætula Lec. "Mammoth Cave," Manitou, Colo.
Anaspis rufa (Say). Georgetown, Colo., about 9,500 feet elevation.
Mordella scutellaris Fabr. American Fork Cañon.

Mordellistena æmula Lec. Golden, Manitou, Colo.
Mordellistena unicolor Lec. Denver, June 27.
Mordellistena pustulata (Mels.). Denver, June 27.
Pentaria fuscula Lec. Manitou, Colo.

MELOIDÆ.

Epicauta pardalis Lec. Southern Colorado (T. M. Trippe).
Epicauta maculata (Say). Golden, Manitou, Colo., on beets.
Epicauta puncticollis Mann. American Fork Cañon, Utah.
Cantharis sphæricollis (Say). Blackhawk, Colo.
Nemognatha dichroa Lec. Denver.
Nemognatha sparsa Lec. Manitou, Colo.
Gnathium minimum (Say). Denver, Golden, July 3.

CURCULIONIDÆ.

Rhynchites bicolor Fabr. Georgetown, Colo., about 9,500 feet elevation.
Ophryastes latirostris Lec. Salt Lake City (Mr. Barfoot).
Dorytomus brevicollis Lec. Denver, Colo.
Anthonomus (not described). Golden, Colo.
Tychius lineellus Lec. var. Denver, Colo.
Baris transversus Lec. Golden, Manitou, Colo.
Sphenophorus pertinax Oliv. Salt Lake City (Mr. Barfoot).

SÇOLYTIDÆ.

Dryocœtes affaber (Mannh). Gray's Peak, 11,200 feet elevation (Kelso's Cabin).
Tomicus pini (Say). Gray's Peak, elevation 11,200 feet (Kelso's Cabin).
Polygraphus rufipennis (Kirby). Gray's Peak, elevation 11,200 feet (Kelso's Cabin).
Dendroctonus obesus (Mann). Blackhawk, July 2; Manitou, July 15.

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Packard, A. S.,

Report on the Rocky Montain locust and other insects now injuring or likely to injure field and garden crops in the western States and territories

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